evoted to
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UARY 14, 1946
UME 35, No. 1

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AMERICAN

DYESTUFF REPORTER

CIAL PUBLICATION
of the
PROCEEDINGS
ICAN ASSOCIATION
TEXTILE CHEMISTS
ND COLORISTS

This first peaceful New Year leaves us all a bit limp after seemingly century-long tension.

Leaves us happy, too, that our men, all too slowly it seems, are returning from lands few knew existed and about which fewer concerned themselves in the past.

Time has changed universally our concept and no longer are we egocentrics, rather are we concerned with the thought of One World—concerned about our neighbors in all quarters of the globe, their happiness and safety as much as our own. For only with their happiness can we be sure of our own.

Let us see that nothing is permitted to stand in the way of a peace which assures forever a Happy New Year.

GEIGY COMPANY, INC.

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Dyestuff Makers Since 1859

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TEA SEED OIL FROM CHINA

"FROM SOURCE THROUGH SULPHONATION— CYANAMID CONTROLS THE QUALITY"

Producing sulphonated oils of uniformly high quality calls for reliable sources of supply for natural oils—plus rigid control over sulphonation. Cyanamid's sources have been carefully selected over a period of many years and are located in many parts of the world. Cyanamid's Tea Seed Oil, for instance, came, and will come again, from areas in China noted for the excellence of their products. Sulphonated in Cyanamid's modern equipment under exacting control, these oils meet the strictest requirements for quality and uniformity. Whatever type you use in your various processes, you can rely on Cyanamid for dependable sulphonated oils made from:

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Each Cyanamid plant manufacturing textile materials maintains a laboratory to rigidly control raw materials and finished products, thus assuring a constantly reliable source of supply.

AMONG CYANAMID PRODUCTS FOR THE TEXTILE INDUSTRY ARE...

Penetrants • Softeners • Finishes
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*Reg. U. S. Pat. Off. **Trade-mark

American Cyanamid & Chemical Corporation

(A Unit of American Cyanamid Company)

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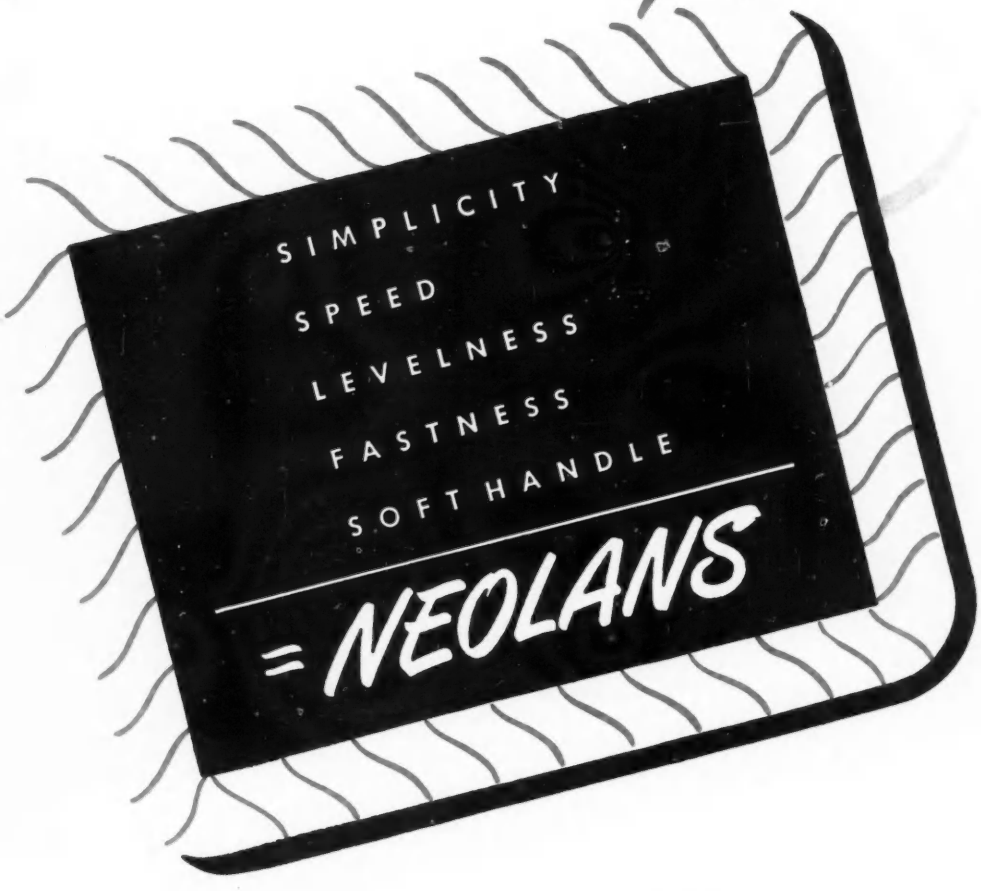
American Dyestuff Reporter, Vol. 35, No. 1. January 14, 1946. Published every other Monday. Copyright 1946, by Howes Publishing Co., One Madison Ave., New York 10, N. Y. Domestic subscriptions, $5.00; Canadian $6.00. Foreign, $6.00. Entered as second-class matter, Nov. 6, 1919, at the New York, N. Y., Post Office, under the act of March 3, 1879.

Add Them Up!



For dyeing fresh pieces
or Redyeing O. D. Woolens

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VAT DYES OF THE DOW CHEMICAL COMPANY

Carnac Makes a Match under "Crown" Tested!

Now, comes Carnac #211, a companion fabric for "Carvanna"! Months ago, Carnac introduced "Carvanna" to the market. You probably remember it. A masculine, fuji-type all viscose rayon fabric, dyed and finished by the North Carolina Fabrics Corp., perfectly suited to men's sport and dress shirts. You probably remember its success too. From the beginning, it has enjoyed excellent distribution among foremost shirt manufacturers and retailers.

Secret of Its Popularity

. . . Is, of course, its reliable service record, as was indicated well in advance by the CROWN Tested "green light" tag it wears. This tag prophesies its ability to launder beautifully, either by machine or commercially. To resist perspiration. Sunlight. Crocking. Atmospheric fading. And it has a residual shrinkage of 1%.

No. 58 of a series from our files on the CROWN* Tested plan

Encouraged by success

Carnac decided to create a companion fabric . . . Carnac #211, for the men's, women's and children's wear field. And today, this delightful fabric makes its appearance distinguished by a thrilling selection of colors, its dependability predicted by the CROWN Tested plan. Carnac is confident that it will receive the same enthusiastic welcome as did the original.

Make a Date With CROWN Tested

If you would promote a happy consumer acceptance of your rayon fabric, why not take the cue from Carnac? Tie in with the CROWN Tested plan today!

*Reg. U. S. Pat. Off.

NEW INFORMATIVE LABELING—CONSUMER SATISFACTION

Under the three tag system . . .

RED DISC for fabrics that can be dry cleaned only

GREEN DISC for washable fabrics

AMBER DISC for hand washable fabrics

"Crown" Tested Rayon Fabric

A better way to buy rayon fabrics—This identification is awarded only to fabrics containing CROWN Rayon, after they have passed the CROWN Tests for serviceability. Samples of every dye lot of fabric have been tested against minimum requirements set and maintained by

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America's largest producer of rayon yarns and staple fibers

Offices: 350 Fifth Avenue, New York 1, N. Y.; Charlotte, N. C.; Philadelphia, Pa.; Providence, R. I.; Washington, D. C.; Wilmington, Del.

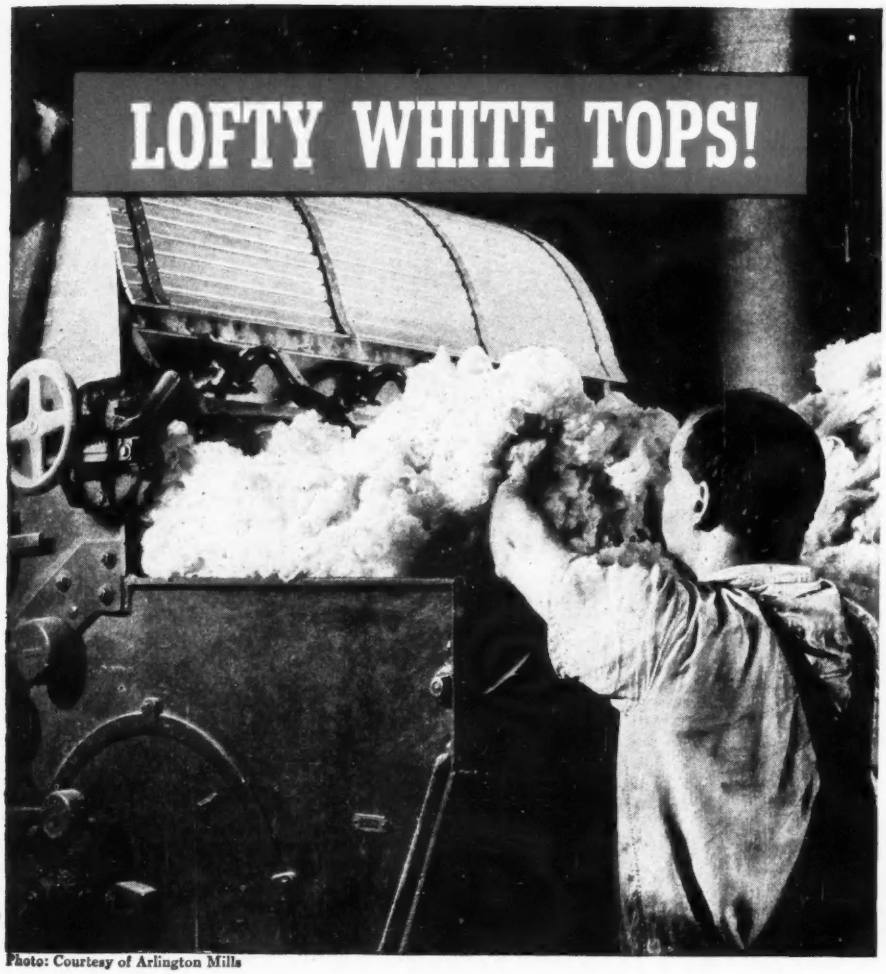

Photo: Courtesy of Arlington Mills

S/V Worstex Oils assure Worsted Tops that Stay White

No need to worry about oxidation and discoloration when you use S/V Worstex Oils in your Worsted processing. These superior oils are light-colored and highly resistant to oxidation.

You can be sure of lofty white tops that *stay* white, even after long storage.

With these oils you also obtain many other advantages. You get uniform drawing and gilling, cleaner drawing rolls, more continuous operation. Spinning is improved, too, particularly on long-draft, high-speed frames. Yarn strength is increased, yarn waste reduced.

Socony-Vacuum makes a complete line of these oils for both Bradford and French-type yarns. Ask your Socony-Vacuum Representative for performance facts and figures.

Better, Lower-Cost PROCESSING for ALL Textiles

WOOLENS
S/V Woolrex Oils

Improve carding and spinning. Scour out easily.

★

WORSTEDS
S/V Worstex Oils

Lubricate stock uniformly, improve spinning.

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WATER REPELLENTS
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Give inexpensive water repellency.

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FINISHING
S/V Finishing Oils

Plasticize starch mixtures.

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S/V Finishing Oils

Insure quick, uniform re-wetting during sanforized processes.

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RAYON PROCESSING
S/V Rayon Oils

Lubricate, soften and deluster rayon fibers.

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Special Oils, Waxes

Provide waterproofing, lubrication and softening.

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S/V Copper-Naphthenates

Prevent fungus growth and increase fabric life.

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announces

DEFINIZED*

TRADE MARK

shrinkage control

for Rayon Fabrics

AQUA·SEC

Developed by ALROSE CHEMICAL CO., PROVIDENCE, R. I.

PATENT APPLIED FOR

It is now possible to control residual shrinkage of **RAYON** *fabrics to within 1%. This achievement is the culmination of years of intensive research. It is called "DEFINIZED"— a wholly chemical action that is simply, easily and quickly applied to goods in the GRAY, without cumbersome machinery, without the use of resins and at far less cost than any other method available today.*

"DEFINIZED" rayon fabrics are fully washable WITHOUT SPECIAL CARE.

"DEFINIZED" rayon fabrics have met all tests in laboratory and actual mill production.

"DEFINIZED" rayon fabrics can now be washed safely at home or by regular commercial laundering without loss of tensile strength and without chlorine damage.

Garments of "DEFINIZED" rayon fabrics can now be correctly sized without necessitating allowance for shrinkage, stretching or distortion.

DEFINIZED
TRADEMARK

NOTE THESE ADVANTAGES of "DEFINIZED" SHRINKAGE CONTROL:

1. Definitely controls shrinkage (less than 1%).
2. Definitely controls stretching (less than 1%).
3. Eliminates chlorine retention in laundering.
4. No loss in tensile strength.
5. No loss in abrasion resistance.
6. Heightens brilliance of white grounds.
7. Gives clearer color definition in dyeing and printing.
8. Sharpens outlines and adds brilliance to colors in printing.

CORPORATION

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REPEL-O-TEX*
THE SUPERIOR WATER REPELLENT
• The marvelous satin-surfaced rayon-and-cotton twill
Forces!
• It will lived in by the
ays water-repellent even after dry-aning—the high-tenacity yarns are rocessed with Repel-o-tex Permanent*.
Designed in two smart raincoats, both beautifully tailored! All inside seams ound. Plump self-covered shoulder pads.
lack, natural, gray in sizes 12 to 20.
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Gift Bond: $1, $2, $5, $10, or $25
Macy's Merchandise Gift Bonds are on sale at Superintendents' Desks on every Macy floor and in the D. A. Dept., 4th Floor. And they're good
REPEL-O-TEX
WATER REPELLENT
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for dyeing and printing
of cellulose acetate

outstanding in

- quality
- money value
- completeness of range

GENERAL DYESTUFF CORPORATION

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4 Hooker Metallic Chlorides of High Purity...

These four Hooker Chemicals are all classified as metallic chlorides, but they can't be grouped under one use or industry heading. Each one, a versatile tool for chemists, may be used in many different processes and in many different reactions. Whether you are looking for catalysts or highly active reagents; whether you are in the petroleum, the textile, pharmaceutical or even water supply field, it will pay you to see if any of these chemicals can help you. If the brief descriptions of these chemicals, their properties and uses whets your curiosity for more information, Technical Data sheets supplementing this data and including Hooker specifications of purity will be sent you when requested on your letterhead.

Aluminum Chloride, Anhydrous, $AlCl_3$ is principally used as a catalyst for Friedel-Crafts synthesis, polymerization, isomerization, halogenation. These reactions are important in the production of high octane gasoline, lubricants, synthetic rubber, dyes, pharmaceuticals, photographic chemicals, etc. Hooker Aluminum Chloride is a grayish crystalline solid which fumes in moist air. It is available in three sizes. It is a particularly pure product containing a minimum by weight of 99% aluminum chloride and a maximum iron content of .05%.

Antimony Trichloride, Anhydrous, $SbCl_3$ is used in the petroleum industry as a catalyst (with $AlCl_3$) to convert normal butane to isobutane and in various hydrocarbon oil treatments. It is also used as a catalyst in organic synthesis; in the manufacture of dyes and pharmaceuticals; preparation of antimony salts; as a mordant in calico printing; in antimony plating; in bronzing iron and other metal treating processes. In a muriatic acid solution it forms a coating of antimony on iron retarding corrosion. Hooker Antimony Trichloride, Anhydrous, is a yellowish crystalline solid of 99% minimum purity. Iron and arsenic are present in a maximum amount of 1% and it is entirely free from lead.

Arsenic Trichloride, Anhydrous, $AsCl_3$ is used in the manufacture of synthetic organic chemicals containing arsenic for insecticides, war and police gases. The Hooker product is a clear, colorless to pale yellow liquid, containing 99.5% minimum, arsenic trichloride.

Ferric Chloride Solution, $FeCl_3$ is used in sewage treatment, in photo engraving, for photogravure and heliogravure, as mordant in dyeing and printing textiles, for the manufacture of other iron salts, paint pigments, iron pharmaceuticals, as an oxidizing agent in making dyes, as a general disinfectant. It is a dark orange-red syrupy liquid with a Ferric Chloride content of 40 to 45% and a ferrous chloride content of .20% maximum.

Help from Hooker Technical Staff

An important function of the Hooker Technical Staff is to cooperate with users and prospective users of Hooker Chemicals. On any of your problems involving chemicals, let our Technical Staff help you in determining where Hooker Chemicals can provide the answer.

HOOKER RESEARCH *Presents*
LAURYL PYRIDINIUM CHLORIDE

$C_5H_5N(C_{12.6}H_{26.2})Cl$

This recently developed product of the Hooker Laboratories has already made its mark in many different applications. The textile field has put Lauryl Pyridinium Chloride to work cleaning textile fibers, in water soluble lubricants, wetting agent in processing, color modifier in dyeing and as a cationic detergent, dispersing and wetting agent in rayon manufacture (Ref. U. S. Pat. No. 2,125,031). Like other quaternary ammonium compounds this chemical has good germicidal properties and is quite potent against both Gram-positive and Gram-negative micro-organisms. For the pharmaceutical industry, this chemical has many interesting possibilities in the preparation of antiseptic soaps, germicides, disinfectants, fungicides, insecticides, etc.

Among other suggested uses for this compound are the manufacture of foam resistant compounds, leveling agent in polishes and waxes; lubricant for plastic molds, additive to water to increase solubility of many organic compounds. Technical Data Sheet 745 gives physical and chemical characteristics and other information. A copy will be sent you on request.

HOOKER ELECTROCHEMICAL COMPANY

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Caustic Soda	**Muriatic Acid**	**Sodium Sulfide**
Paradichlorbenzene	**Chlorine**	**Sodium Sulfhydrate**

8351

Powerful

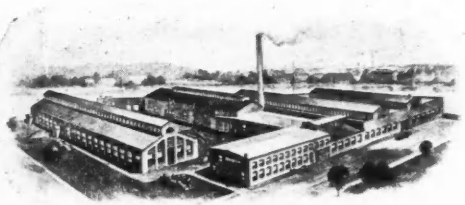
IS THE WORD FOR

SULFRAMINE DT*

Ultra's amazing new POWDER detergent

Leading textile mills are finding Sulframine DT an exceptionally efficient and economical detergent. Chemically classified as an alkylaminosulphate, it can be utilized in almost every phase of boiling off and dyeing. As an emulsifier and foaming agent, Sulframine DT dissolves readily, and it will form rich suds even in dilutions of one to ten thousand or more parts of water. Not even the most severe water conditions can affect its phenomenal properties.

Sulframine DT is totally immune to lime and magnesium salts . . . resistant to acids and alkalies . . . and will not deteriorate in storage. In fact, it can replace soap, eliminating the dangers of rancidity and stains left by unrinsed soap particles. Too, the thorough dispersing qualities of Sulframine DT make it an ideal dyeing assistant for rayon and acetate fabrics. Let a test prove your need for Sulframine DT. One of our technicians will be glad to bring you a practical mill run sample.



NOTE: Sulframine DT has potent commercial uses in dozens of other industries: Dry Cleaning, Dairy, Steel, Insecticide, Cosmetics, and Household Preparations. Wire or write—today—for more detailed information.

ULTRA CHEMICAL WORKS

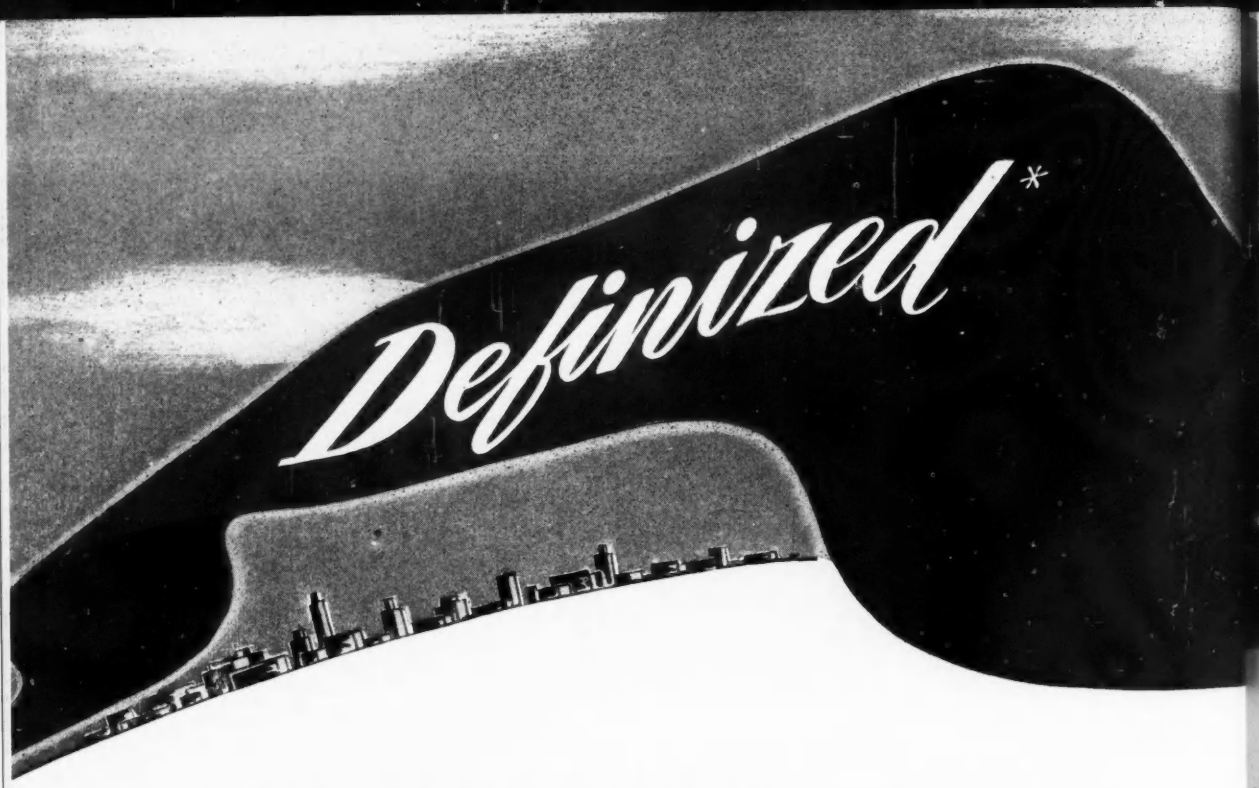
INCORPORATED

Paterson, N. J. Chicago, Ill.

OTHER ULTRA CHEMICAL PRODUCT DEVELOPMENTS . . . ULTRAMINE • DETERGOL • SULFRAMINE DT PASTE SULFRAMINE DR PASTE • SULFRAMINE POWDER • ALBUTEX • ALBUTINE • DERMASOL • ULTRA GLOSS • DULLITE T

*Sulframine DT is made from an exclusive formula—U. S. Pat. Pending

SULFRAMINE DT—REG. U. S. PAT. OFF.



A New FAR-REACHING WORD on the Textile Horizo

DIMENSIONAL STABILIZATION OF FILAMENT RAYON, SPUN RAYON OR RAYO MIXTURES INCLUDING WOOL, BY A SIMPLE METHOD . . .

- A method that does not retain chlorine.
- A method that does not use resin.
- A method that uses existing equipment.
- A method that produces durable results by physical change of the fiber.
- A method that is low in cost.
- A method with 100% Laboratory control.

THESE NEW AND IMPORTANT "DEFINIZED" STEPS ADD UP TO

SHRINKAGE	0 to 1%
CHLORINE RETENTION	0
CHEMICAL RETENTION	0
TENDERING	0
ODOR	0
DERMATITIS	0
HAND	excellent

These are but a few of the many new advantages offered by the DEFINIZED process.

We do not ask you, however, to accept any of these "DEFINIZED" claims at face value. Instead we suggest an appointment for a demonstration in your plant . . . let the results tell their own story.

***"DEFINIZED"**
Is A *Licensed* Process

Merchandising plans to be announced later.

***FILL IN THE APPOINTMENT CARD . . . MAIL IT IN* TODAY.**

Gentlemen:

Please arrange an appointment for a demonstration of stabilization by the Definizing process.

PLANT .....

ADDRESS .....

SENDER .....

TITLE .....

REMARKS .....

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AQUA-SEC CORP., SALES AGENTS, 1450 Broadway, N. Y. C.

PERKINS AUTOMATIC BIN PILERS

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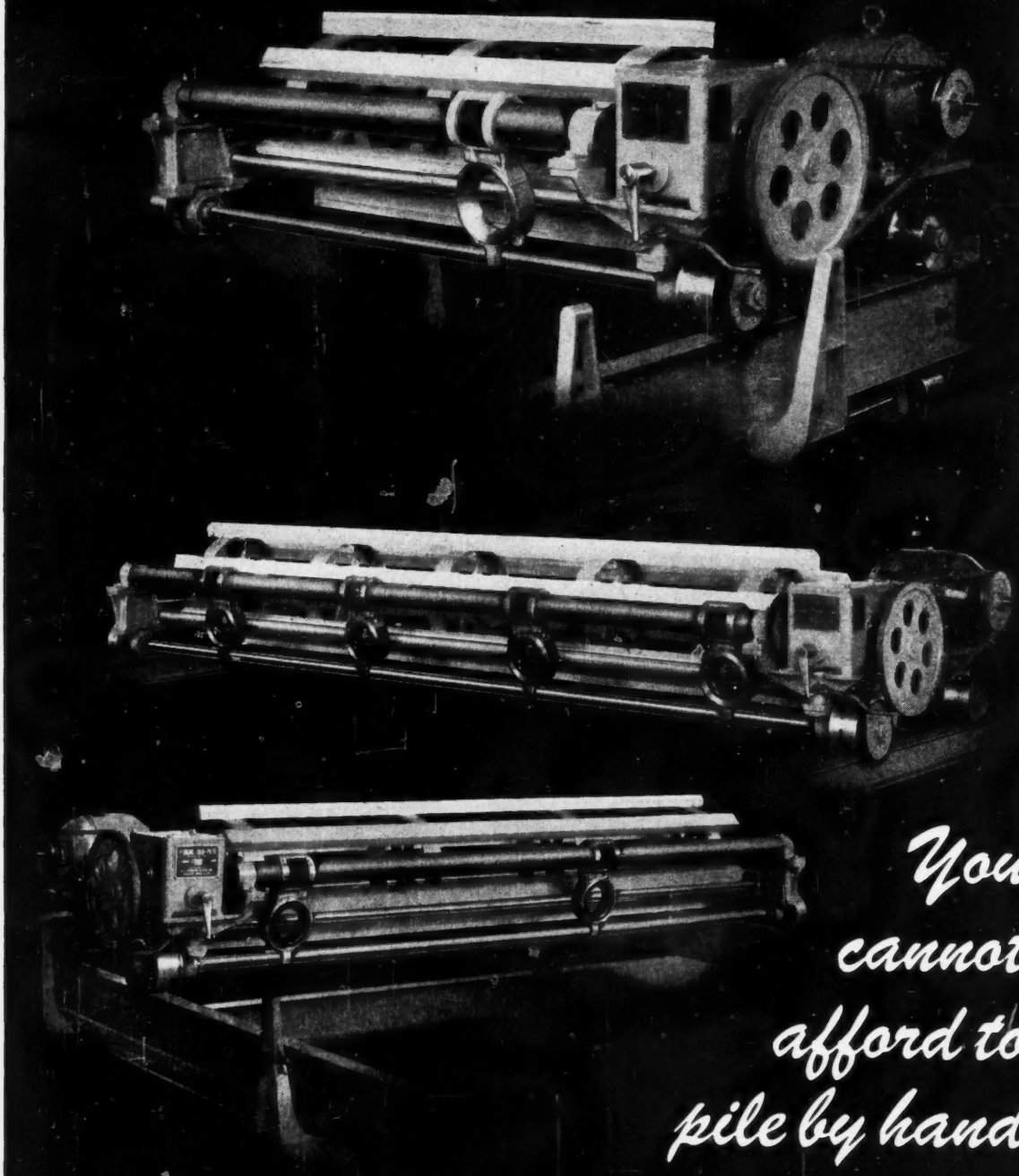


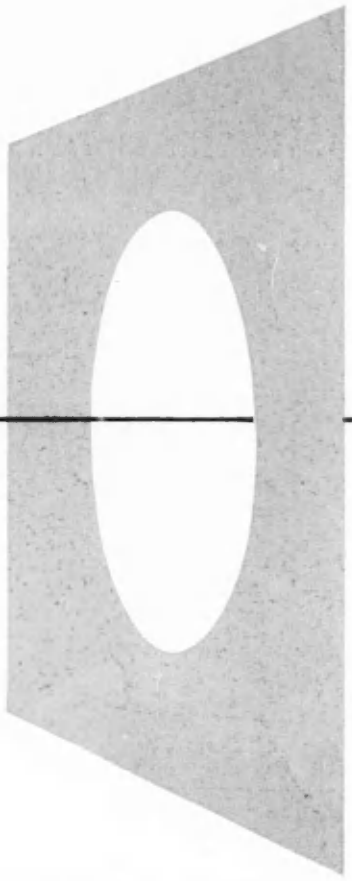
You cannot afford to pile by hand

B. F. PERKINS & SON, INC.

ENGINEERS AND MANUFACTURERS

HOLYOKE • • • MASSACHUSETTS

EASTONE* ORANGE 2R
Concentrated



Eastone **Orange 2R Concentrated*** gives excellent results when used on cellulose acetate rayon as a base in compounding browns, rusts, tans, grays, blues, and greens. It is also highly recommended as a component of the pastel shades of these colors. Orange 2R Concentrated is one of the few acetate dyestuffs which will dye nylon a true orange color. In application printing, it is used to print acetate or nylon fabrics bright shades of golden orange.

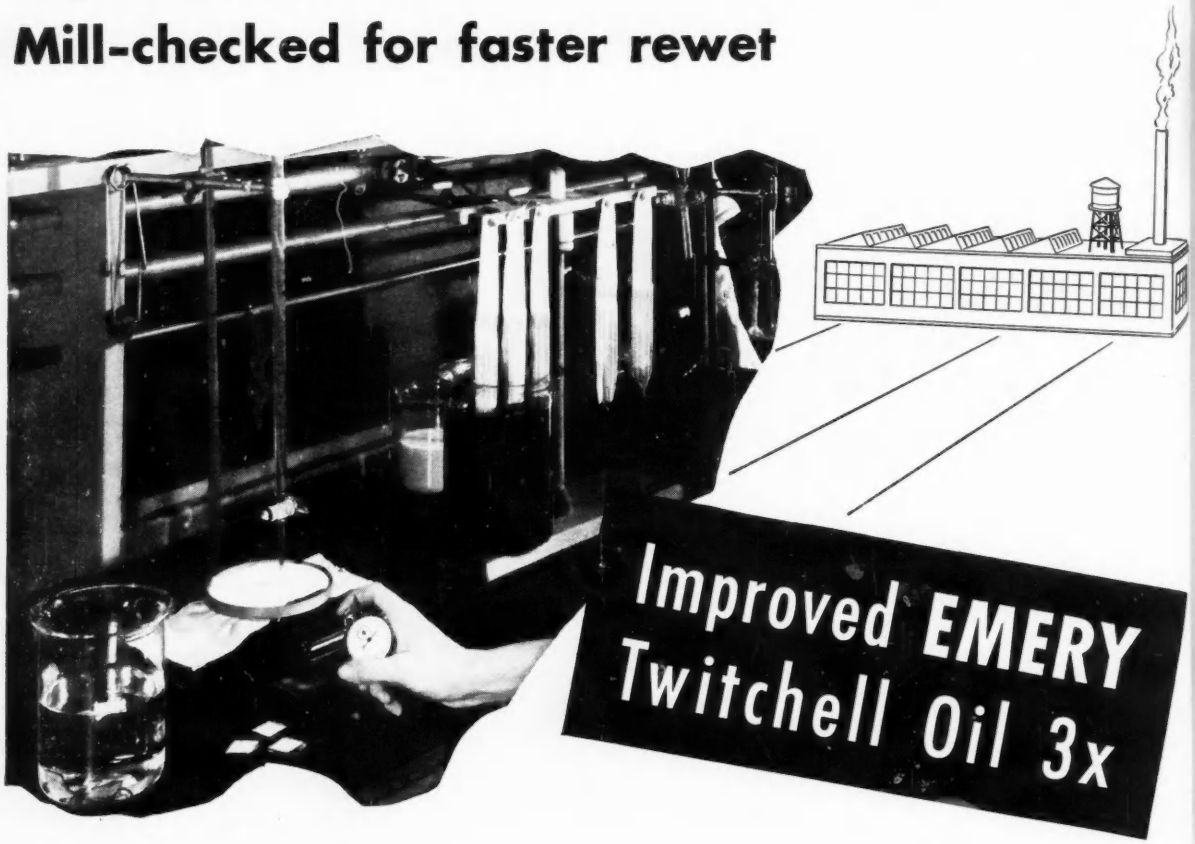
Resistance of Orange 2R Concentrated to gas fading, sublimation, washing, and crocking is high. Solubility is excellent, and, dyed over a temperature range of 160° F. to boiling, level dyeings with good exhaustion are produced. Either a box or a jig may be used.

Eastman Acetate Dyestuffs offer a wide variety of colors especially developed for the dyeing of cellulose acetate rayon fibers and the fabrics in which they are used. For information on Eastman Acetate Dyestuffs and their application to synthetic fibers, write to TENNESSEE EASTMAN CORPORATION (Subsidiary of Eastman Kodak Company), KINGSPORT, TENNESSEE.

EASTMAN ACETATE DYESTUFFS

**"Eastone" is a registered trade mark and denotes a type of dye which is dischargeable, as well as usable for plain dyeing.*

Non-Staining Oil for Sanforized Finishing...
Mill-checked for faster rewet



Because some tests tend to measure *wetting out* times, laboratory results do not always check with the speed and uniformity of *wetting back* which occurs under the Sanforizing sprays. Rely on mill tests to prove the efficiency of Emery's Improved Twitchell Oil 3X. Note:

1. Uniform and rapid rewetting which promotes a high yardage output on Sanforizing machine.
2. Retention of rewet properties of fabrics stored after finishing and prior to Sanforizing—No oxidation nor staining.
3. General increase in efficiency because Twitchell Oil 3X is anhydrous, contains no volatile ingredients; imparts lubricity to fabrics reducing friction of Sanforizing shoes; causes no tackiness on shoes or gumminess in or deterioration of the Palmer blanket.
4. Compatibility with starches and other ingredients of regular finishing formulae. Used in warp sizes, Oil 3X adds pliability and rewetting properties . . . Fabrics can be Sanforized direct from looms.

★

TYPICAL RESULTS OF NEW TWITCHELL OIL 3X by tentative AATCC Drop Test for evaluating rewetting agents

Peroxide-bleached shirting . . Aver. 10.9 secs.

No. 8 Canvas Duck . . . . . Aver. 8.4 secs. at 2% concentration.

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EMERY INDUSTRIES, Inc.

STEARIC ACID • OLEIC ACID • ANIMAL, VEGETABLE AND FISH OIL FATTY ACIDS
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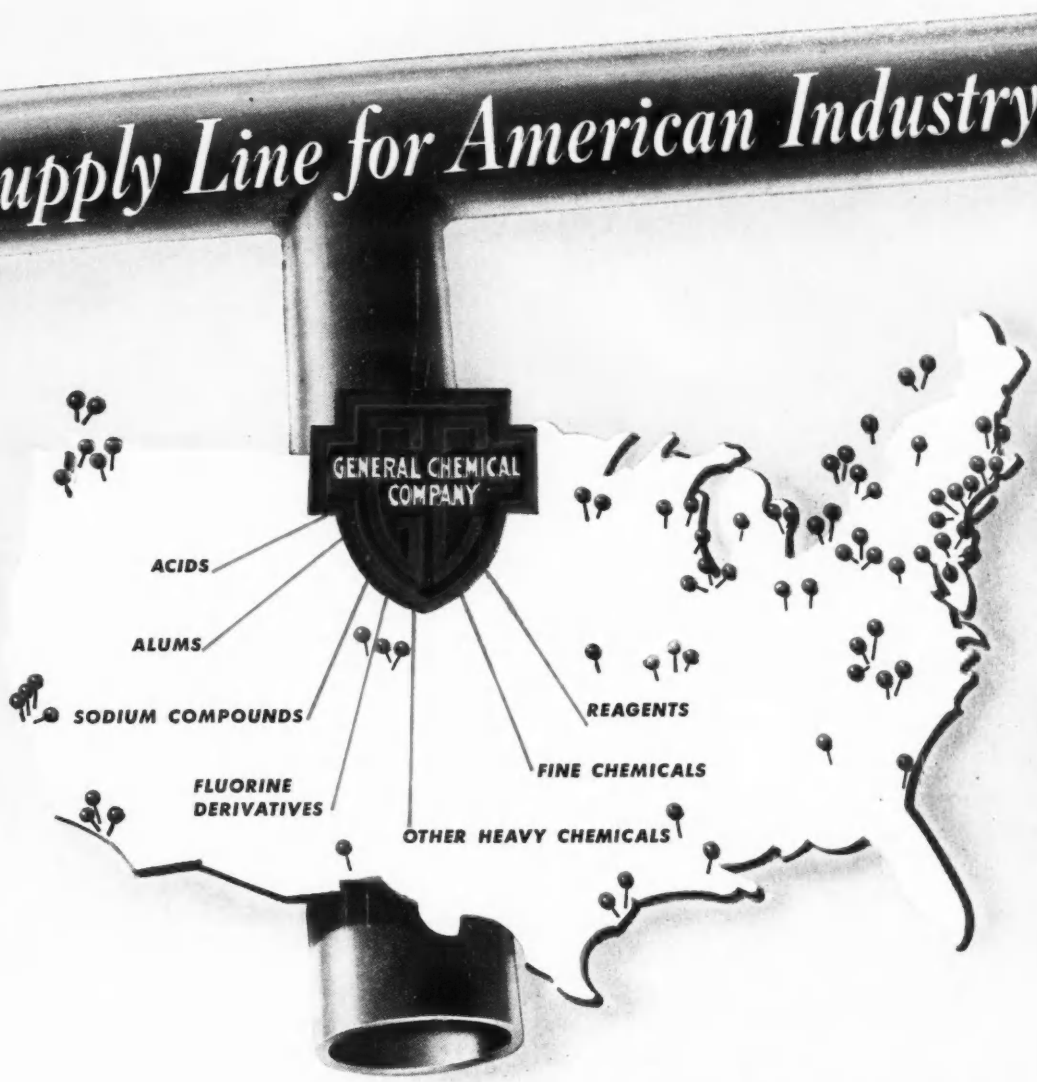
Supply Line for American Industry...



Here is the supply line of Basic Chemicals for American Industry. North, South, East or West . . . wherever the needs are greatest . . . there, too, are the heaviest concentrations of General Chemical *plants, warehouses,* and *technical service offices*—equipped and prepared to meet the chemical demands of the day.

For almost half a century, this supply line has grown ever stronger. It spans the continent . . . reaches out to the most remote locations . . . always maintaining the full flow of a broad and varied range of chemicals so necessary to peak production.

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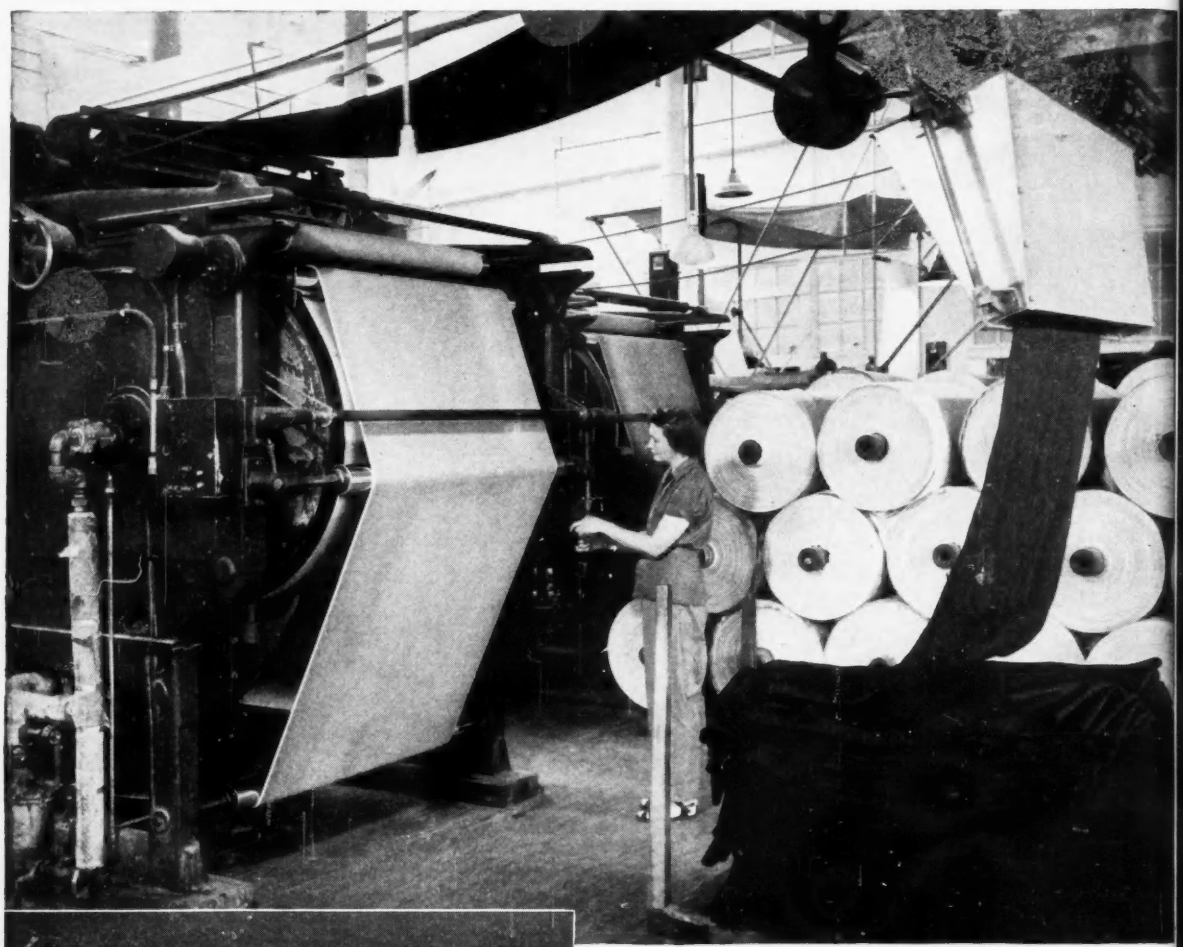

Photograph courtesy Renfrew Bleachery, Travellers Rest, S. C.

FOR FASTER MORE UNIFORM *Sanforizing* USE

NOPCO 2272-R

For Instantaneous Rewetting

● NOPCO 2272-R can step up the volume and quality of sanforized goods, because this homogeneous, hygroscopic clear oil is easily soluble in water and capable of imparting instantaneous rewetting. Its exceptional penetrating qualities assure more uniform shrinkage during the sanforizing operation.

OTHER ADVANTAGES — NOPCO 2272-R resists oxidation — causes no odor or discoloration — is completely miscible with finishing oils — provides lubrication that makes fibers soft and pliable without becoming greasy or slippery. Through rapid wetting or rewetting at low concentrations, NOPCO 2272-R reduces costs.

A dependable wetting and rewetting agent is *indispensable* to uniform sanforizing. If you are not getting controlled shrinkage, it will pay you to change to NOPCO 2272-R now. For further particulars, write

NATIONAL OIL PRODUCTS COMPANY, Harrison, N. J.

Branches:

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NOPCO REG. U. S. PAT. OFF. **EVOLVED THROUGH RESEARCH**

When a fabric has "a soft mellow hand" the odds are that the dyer and finisher is a customer of ours.
PERMA-PAR PERMANENT FINISHES ARE OUTSTANDING IN EXCELLENCE AND PROVEN ECONOMY.
OUR STAFF OF TEXTILE CHEMISTS AND BACTERIOLOGICAL SCIENTISTS IS AVAILABLE TO OUR CUSTOMERS.
REFINED PRODUCTS COMPANY
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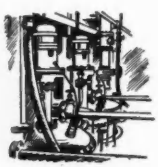

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Proceedings of the
American Association of Textile Chemists and Colorists

JANUARY 14, 1946

Record Attendance at VICTORY CONVENTION

THE Victory Convention, held under the auspices of the New York Section at the Hotel Pennsylvania, New York City, on January 3rd, 4th and 5th, attracted a total of over 1350 registrants, the highest number to date of any convention. In addition several hundred of the general public took advantage of the opportunity which was given them to examine the exhibits on Saturday afternoon. The attendance at the President's Corporate Membership Dinner was approximately 550 and at the Annual Banquet around 800.

The exhibitions were the most ambitious of any ever attempted at any convention of the A.A.T.C.C. and proved to be of extreme interest to all branches of the textile field. Photographs of the various exhibits will appear in future issues of the REPORTER.

EMMETT J. DRISCOLL
General

All of the technical sessions were well attended by a serious minded audience. These papers will be published in their entirety in the near future; it is planned that a great many will appear in the February 11th issue. The proceedings of the Corporate Membership Dinner and the Annual Banquet will also be published in full.

INTERSECTIONAL CONTEST

At the annual banquet it was announced by Kenneth H. Barnard, Chairman of the Intersectional Contest, that the following were the winners: 1st Prize—Rhode Island Section; 2nd Prize—Northern New England Section; 3rd Prize—New York Section. All of the contest papers appear in this issue.

NOTE: The members of the Executive Administrative Committee for the Victory Convention are shown on this page.

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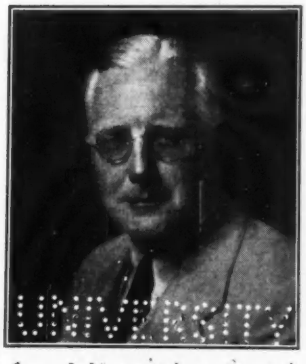

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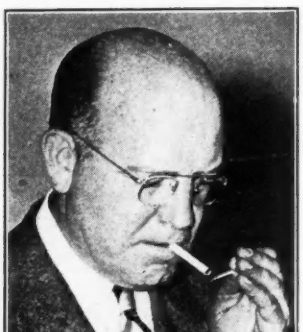

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FOR COMPLETE REPORTS
OF THE VICTORY CONVENTION

Intersectional Contest ☆ First Prize ☆

FACTORS WHICH CAUSE OR PREVENT AGGLOMERATION OF PIGMENT PARTICLES*

Presented by the
RHODE ISLAND SECTION

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FRANCIS TRIPP

Paper Presented By
RAYMOND W. JACOBY

IN THE Intersectional Contest Paper submitted by the Rhode Island Section in 1944, entitled "Factors Affecting Color Yield in Vat Color Printing," it was shown that agglomeration of pigment particles can cause a very substantial loss in color yield. Inasmuch as coloring materials in pigment form are used extensively not only in vat color printing, but in many other ways, it was thought a study to determine what factors or properties cause or prevent this agglomeration would be of material value, and accordingly this work was undertaken by the Intersectional Contest Committee of the Rhode Island Section.

As this work was entirely exploratory, the first step was to consider what factors might be expected to influence the stability of pigment dispersions. Then experiments had to be devised in order to assess the importance of these factors. The phenomena studied can be classified under the following four headings:

1. Electrical charge on color particles.
2. Hydration of color particles.
3. Nature of the colloidal dispersion of the thickener.
4. Effects of finely divided solids.

As the work progressed, tests which were made in consideration of one of the points revealed results which came under other points, and it has been decided that rather than give the details in chronological order, the points be discussed individually under their respective headings.

In order to eliminate variables due to different types of pigment dispersion, all of the experiments were made with the same vat color paste, namely Ciba Blue 2BDG Double Paste—C.I. 1184.

The presence or absence of agglomeration was determined by microscopic examination of dispersions of the pigment in various media, and by making prints on cloth. For the record, photomicrographs† were made of the dispersions in different media and under varying conditions which are shown herewith on Plates I, IIa, IIb, III, IVa, and IVb. Spectrophotometric charts of printing paste and prints were made and are shown herewith on the Plate of Spectrophotometric Charts.

1. ELECTRICAL CHARGE OF COLOR PARTICLES

As the importance of electrical charge in colloidal systems is well known, qualitative measurement of the charge on color particles was undertaken. An apparatus was made, utilizing the principle that dispersed particles will move under the influence of an electric current. In this apparatus, direct current is passed through a piece of wet filter paper. A drop of the dispersion under test is placed on the paper and the dispersed charged particles are seen to move toward the oppositely charged electrodes. It should be mentioned that this apparatus cannot be used on such fine dispersions as solutions of direct dyes, it being necessary to use a cataphoresis cell on those systems.

The apparatus constructed in the laboratory consisted primarily of a piece of plate glass 4"x3"x7/16" with copper electrodes fastened to the glass along the 3" sides. The electrodes used are 4¼" long long by ⅝" wide and are fastened to the plate in such a manner that a surface 3" long and 7/16" wide is in contact with the wet filter paper clamped on the glass plate by the electrodes. Direct current (110 volts) is passed through the wet filter paper for 10 seconds to 1 minute according to the type of dispersion being tested.

As a safety measure, the glass plate and the electrodes were housed in a box, about 10"x10"x10", constructed with a sliding glass door. The wiring is so arranged that there is no current passing through the electrodes when the sliding door is open, and it is only when the door is tightly closed that there is any current present. A light bulb was wired with the electrodes so that it would be lighted when the current was "ON" and off when contact is broken.

Test papers to determine polarity, that is, the positive and negative electrodes, can be easily prepared by soaking strips of heavy blotting paper or filter paper in a 10% solution of Potassium Chloride containing 1% Phenolphthalein. The strips are then dried and can be kept until ready for use. To determine polarity, a strip of the impregnated paper is dampened with water and clamped on the glass plate with the electrodes. The current is turned on for 10 seconds or until a distinct red color appears at one of the poles. The red color indicates the negative pole, which can be noted. The electrodes should be thoroughly washed and dried after each determination as the decomposition products, that is, chlorine and potassium hydroxide, corrode the copper electrodes.

To determine the charge carried by certain colloidal systems such as rubber latex emulsion or a dyestuff paste, a piece of heavy filter paper, cut to fit the plate glass, is dampened with distilled water and clamped in place by the electrodes. A large drop of the dispersion is placed as near the center of the filter paper as possible. The current should be turned on just before putting the drop on the filter paper or at the same time so the dispersion does not have time to coagulate, soak into the filter paper, or spread before the current has time to act on the charged particles. The dispersed particles will tend to migrate toward the pole with a charge opposite to that carried by the particles.

It has been found in the laboratory tests made that all vat pastes tested carried a negative charge. The amount, or degree, of the charge does show con-

* Presented at Intersectional Contest, Victory Convention, Hotel Pennsylvania, New York City, January 5, 1946.

† All photomicrographs were made at 430 magnifications.

siderable variation in different pastes, some showing a strong negative charge, while others a very weak negative charge. Determinations of other colloidal systems have been made and are in accordance with findings by other workers.

A number of commercial vat color pastes were then tested and the following results noted:

Slight Negative Charges:

Ciba Brown G Double Paste Extra New
Ciba Blue 2BDG Double Paste
Ciba Orange RDL Paste
Ciba Red 3B Double Paste
Ciba Pink FF Paste
Cibanone Brown GR Paste
Cibanone Olive 2R Paste

Medium Negative Charge:

Ciba Brilliant Red 2GN Double Paste
Cibanone Yellow GC Double Paste
Cibanone Navy Blue RA Double Paste

Strong Negative Charge:

Ciba Scarlet G Double Paste

As all of the vat pastes tested showed that the pigment particles carried a negative charge, it was assumed that the introduction of an electrolyte carrying a positive charge would cause agglomeration. Solutions of salts containing mono—, bi— and trivalent cations were made and Ciba Blue 2BDG Double Paste was added to each. It was found that as the amount of positive charge on the ion increased from 1 to 2 to 3, the amount of agglomeration increased. (See Plate I and Experiment A.) This shows that when pigments carry an electrical charge, introduction of electrolytes carrying a strong opposite charge can cause agglomeration. Electrolytes of this nature probably would not be encountered in vat color printing pastes except as impurities but it is advisable to add small amounts of phosphates, such as sodium hexameta phosphate and sodium tetraphosphate, carrying a strong negative charge to prevent agglomeration. In some other applications of vat color pigments this condition might be encountered. In fact in a recent case in practice a coating compound was prepared using a latex dispersion and aluminum carboxy-methocel as a thickener together with vat color paste for coloring. In this mixture bad agglomeration of the pigment particles occurred. Replacing the aluminum carboxy-methocel with sodium carboxy-methocel overcame the agglomeration.

2. HYDRATION OF COLOR PARTICLES

Since vat color pastes are water dispersions, and the pigment particles are considered to be hydrophilic, it would be expected that the addition of substances having strong affinity for water would weaken the water envelope surrounding the pigment particles, and thereby promote agglomeration.

In confirmation of these ideas it was found that anhydrous ethyl alcohol or silica-gel when added directly to the vat color paste caused agglomeration. If these materials are first added to another aqueous phase so that they become hydrated and vat color paste is then added to the mixture, no agglomeration occurs. (See Experiment B and Plate IIa).

Gelatinized corn starch has strong affinity for water. If a vat color paste is added directly to a starch paste the color agglomerates. If, however, the vat color paste is first added to water, so that there is an excess of water to protect the dyestuff, and the mixture then added to corn starch, there is minimum agglomeration. If the addition of the same amount of water is made to the starch paste and the vat color paste then added to the diluted starch paste, agglomeration occurs. (See Experiment C and Plate IIb).

These tests seem to substantiate the theory that any action which disturbs the envelope of the vehicle around the color particle affects dispersions. This action is also demonstrated in mixtures of pigments in oil where oftentimes additions of fatty acids are made to facilitate "wetting" of the pigment particle so as to obtain better dispersion. Maximum color yield or depth of shade depends upon complete dispersion of the color pigment as agglomeration causes reduction in color yield or depth of shade. (1)*

3. NATURE OF THE COLLOIDAL DISPERSION OF THE THICKENER

In many cases of the application of pigments it is desired to have a viscous medium as the vehicle. In these cases various "thickening" agents, such as starches, converted starches, gums, soluble forms of cellulose, etc., are used. Most of these "thickening" agents form colloidal dispersons possessing various properties. There is a great scarcity of information as to the structure of these dispersions and Hauser (2)* cites several different theories. Though lacking knowledge of what the structure is, it was felt that differences might exist which could cause agglomeration. Accordingly, experiments were undertaken to give such empirical information as could be found, even though an acceptable general hypothesis to explain the data was lacking.

To study the effect of "thickeners," pastes were prepared of various thickening agents and water. These were of similar viscosity and all had "printable body." Vat color paste was added to each different "thickener," the resultant mixture examined under the microscope and then prints were made. (See Experiment D). The results of this test showed a range of from complete agglomeration of all of the color to practically no agglomeration. This indicated that there was some property of these various thickeners which had a material effect upon the dispersion of the color. A number of further experiments were made in an effort to determine what properties caused this effect. No satisfactory answer was found and it confirmed the statement frequently made that very little knowledge is had regarding the structure of a colloidal dispersion; for example, a paste made with 16 gr. corn starch, 304 cc water, heated to 200°F. for 15 minutes, then cooled to room temperature gives a thick paste. When vat color is incorporated into this paste it entirely agglomerates. Other pastes were then prepared using the same amount of corn starch and water, but adding 4, 8, 12, and 16 grams of British Gum, respectively. Although these other pastes had increasing amounts of total solids, they became thinner as the amount of British Gum increased. Also the dispersion of the vat color in them became better until a point was reached where there was minimum agglomeration. On the other hand, as shown in Experiment C when starch paste is thinned down with water there is no improvement in the dispersion. Further trials were made to determine the ratio of corn starch: British Gum at which point agglomeration stopped. The ratios of corn starch: British Gum used were: 4:1, 4:2, 4:3, 4:4, 4:5, 4:6, 4:7, 4:8. Four grams of vat color paste were added to 60 grams of each of the above pastes. The resultant mixtures were examined under the microscope and prints made. It was found that with the ratio of 4 parts of corn starch to 3 parts of British Gum there was minimum agglomeration, the color was fully dispersed and a good full print was obtained.

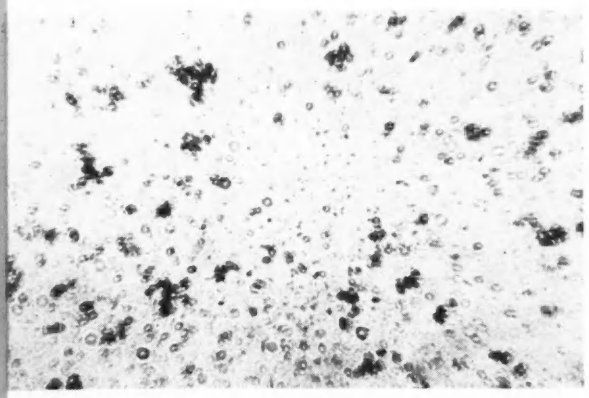
The thought was advanced that the presence of British Gum retarded the gelatinization of the corn starch. In order to investigate this possibility, corn starch and British Gum pastes were cooked separately, then added together to give mixtures as above, color was added, the pastes examined under the microscope and prints made. These showed improved dispersion as the amount of British Gum increased, and at the ratio of 4 parts of corn starch: 3 parts of British Gum there was minimum agglomeration and a full shade print was obtained.

In the foregoing description of tests with corn starch and British Gum, when we mention minimum agglomeration we mean that which is not visible with low magnification (40x) or on the print; however, that there is slight agglomeration is shown by the results of tests to be de-

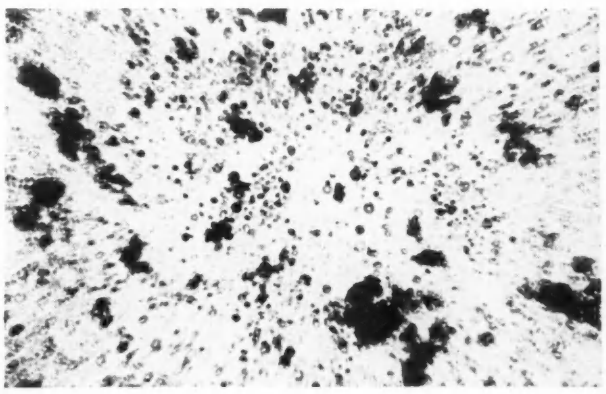
* Figures in parenthesis refer to references at end of paper.

PLATE I
EFFECT OF ELECTROLYTES
5 Grams Vat Paste—100 c.c. Solution

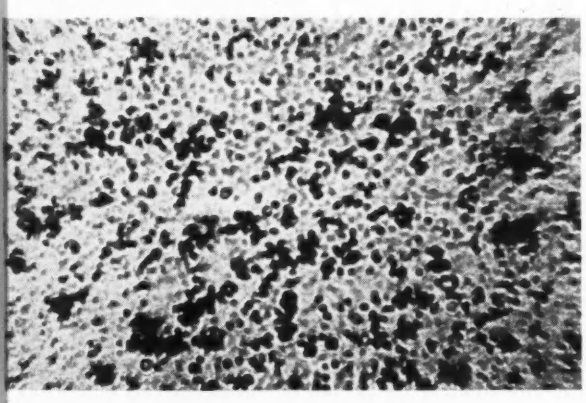
1. Water



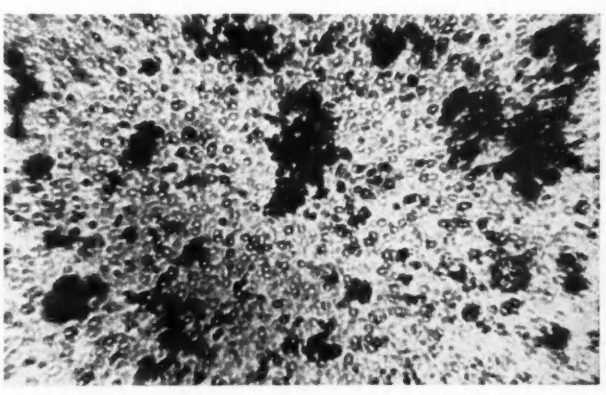
2. 1% Sodium Chloride pH 6.0



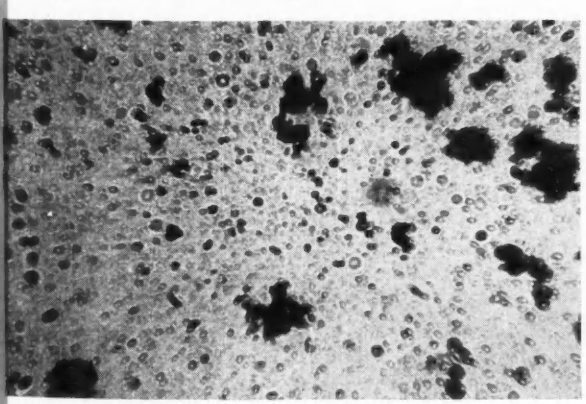
3. 1% Calcium Acetate pH 6.0



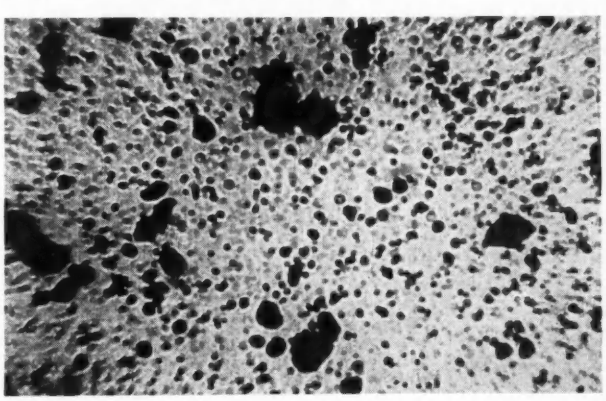
4. 1% Chromium Acetate pH 6.0



5. 1% Sodium Carbonate pH 11.1



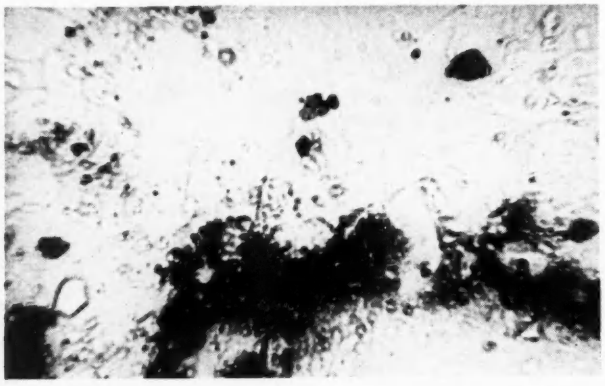
6. 1% Trisodium Phosphate pH 10.9



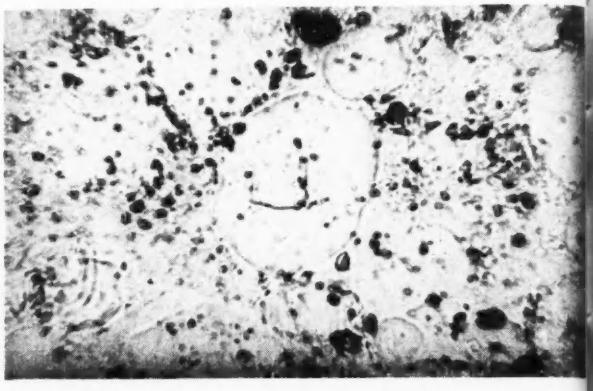
scribed under Sec. 4 where benefits from addition of fine divided solids are given. These tests show that evidently there is some property of the colloidal system which in some cases affects the dispersion of the pigments. This is further indicated by plant experience where differences in cooking times or temperatures with the same thickener, or cooking with or without alkali present, gives varying results particularly as regards color yield due to agglomeration. The different degrees of agglomeration with various thickeners are shown in the photomicrographs on Plate III, Nos. 16, 17, 18, and 19. Previous publication (1)* described the action of glue in conjunction with vat color pastes. The question arose as to

PLATE IIa
EFFECT OF HYDRATION OF COLOR PARTICLE

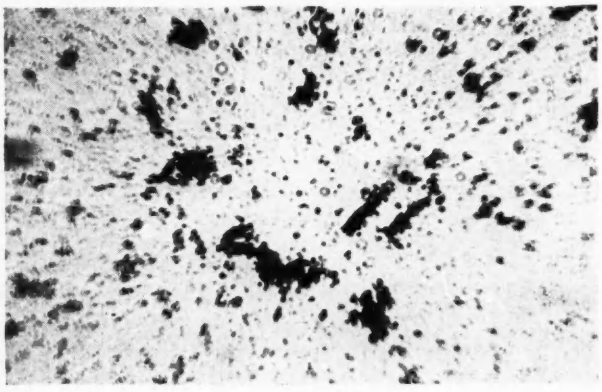
7. Corn Starch, British Gum, Water, Color—Silica Gel added



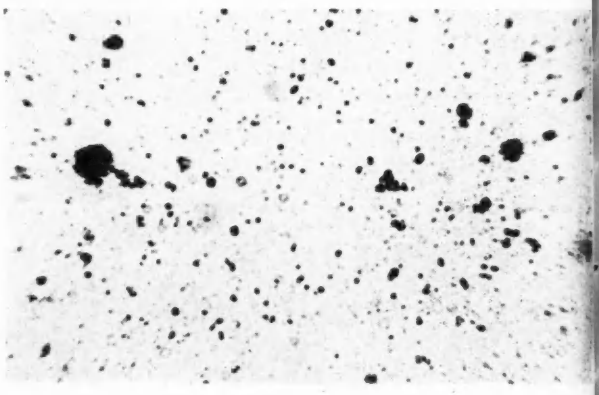
8. Corn Starch, British Gum, Water, Silica Gel—Color added



9. Anhydrous Alcohol and Color mixed and added to Water



10. Anhydrous Alcohol and Water mixed and Color added.



whether or not very small amounts of glue might provide a protective coating without the adverse effect of larger amounts. It was found that if, in a starch-British Gum paste, glue up to 0.3% was added there was an improvement in the dispersion of the pigment. As the amount of glue present increased over this amount, the agglomeration became worse. This effect is shown on Plate III, Nos. 20, 21. This would seem to indicate that some hydrophilic material could be found which would strengthen the water envelope around the color particle to a greater degree.

4. EFFECT OF FINELY DIVIDED SOLIDS

It has been established (3)* that if solid particles of various size are mixed, the smaller particles tend to coat the larger particles. It was thought that this action could be utilized by adding fine particles of insoluble material to the vat color paste. Then, depending upon the size of the color particles and of the particles of the added material, one would coat the other and prevent the color particles from agglomerating and adhering to each other. As there are on the market quite a few insoluble and relatively inert pigments of fine particle size it was decided to experiment with them. Examples are: silica, diatomaceous earth, aluminum oxide, silica gel, bentonite, syton (colloidal silica), calcium sulphate, and calcined calcium sulphate. In the balance of this discussion we will refer to these materials as "inerts" as they are used only to demonstrate the effect of small particles and are not considered to enter into any reaction. The inerts were added to water, then mixed into stock starch-British Gum paste. Vat color was added and the mixtures examined under the microscope and prints made. The dispersion of the pigment under these conditions is shown in Plate IVa and Plate IVb and described in Experiments E and F. The alumina and silica were obtained in two different particle sizes and are referred to as "coarse" and "fine." The size of the particles of the vat color was from 0.5 to 15 microns—average 4 microns. The particle size of the inerts was as follows:

	Particle Size in Microns		
	Maximum	Minimum	Mean
Calcium Sulfate (anhydrous)	250	6	20
Calcium sulfate	3	1	2
Fine Silica	4	1	1–2
Coarse Silica	125	50	
Fine Alumina	4	1	2
Coarse Alumina	125	50	
Bentonite	5	1	
Silica Gel	50		
Syton (Colloidal Silica)			0.04
Diatomaceous Earth	65	1	

It is seen from these figures that of the inerts used one was much smaller in particle size than the color, some had a particle size in the range of the color, and some had a particle size much larger than the color. All of these materials with the

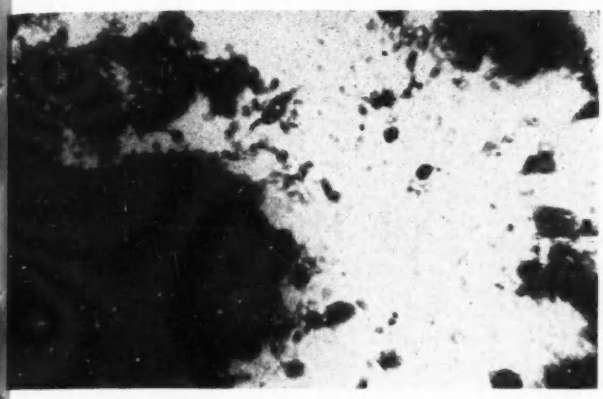
* Figures in parentheses refer to reference at end of paper.

PLATE IIb

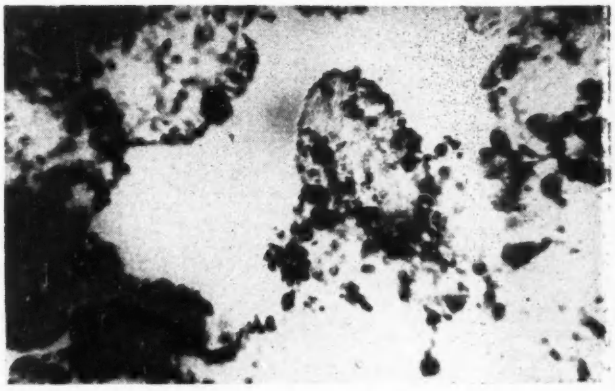
EFFECT OF HYDRATION OF COLOR PARTICLE

5% Cornstarch Paste Series

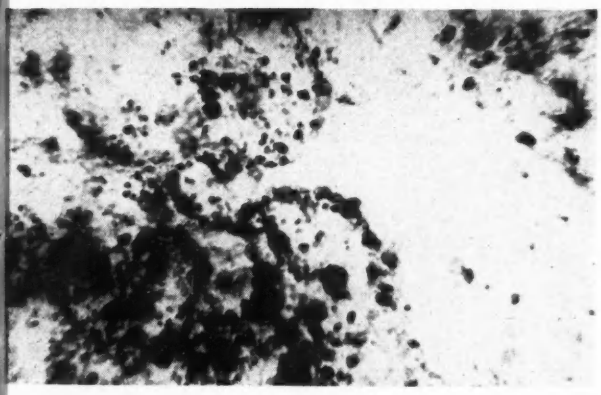
11. 30 Gms. Paste, 30 Gms. Water—5 Gms. Color added.



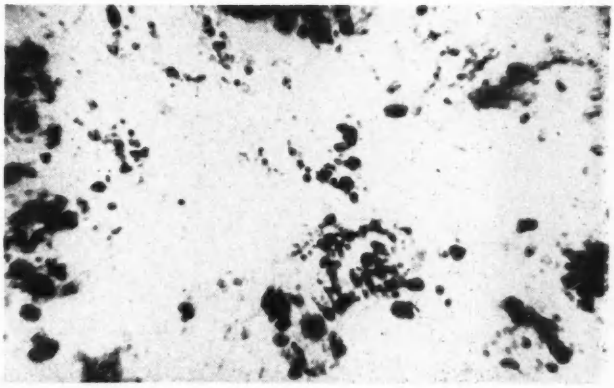
12. 30 Gms. Paste, 20 Gms. Water—5 Gms. Color and 10 Gms. Water mix added



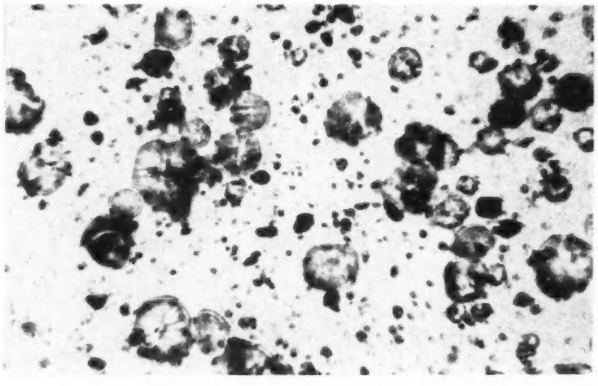
13. 30 Gms. Paste, 10 Gms. Water—5 Gms. Color, 20 Gms. Water mix added



14. 30 Gms. Paste—5 Gms. Color and 30 Gms. Water mix added



15. Cornstarch Uncooked, Water, Color



exception of the calcium sulfate, which will be discussed later, when added to the starch-British Gum paste improved the dispersion.

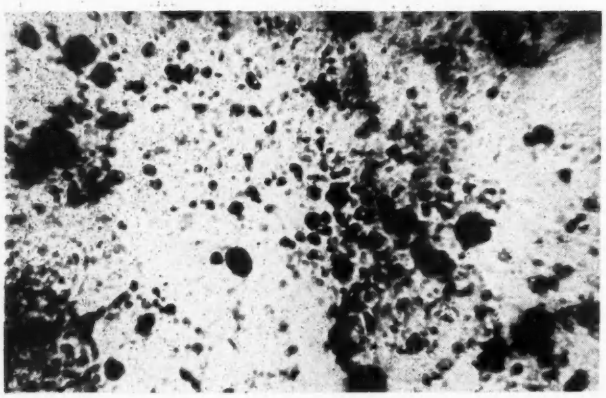
An experiment (See Experiment F) was made using silica of different particle sizes. These were:

Syton (Colloidal Silica)..particle size 0.04 microns
Fine Silica.....particle size 1–4 microns
Coarse Silica.....particle size 50-125 microns

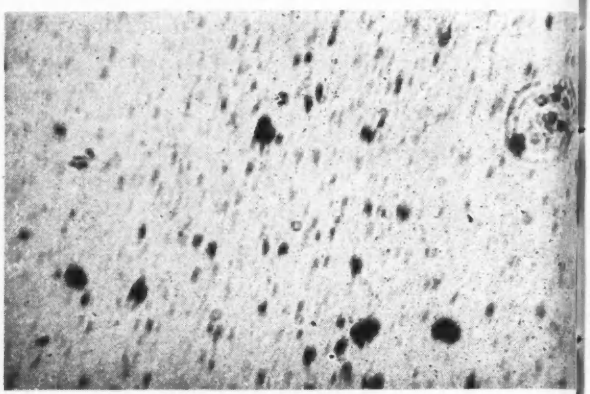
These were used in conjunction with a starch-British Gum paste. This gave inert particles below, in, and above the range of particle size of the color. Photomicrographs of these plates are shown on

PLATE III
COLLOIDAL STRUCTURE OF THICKENER

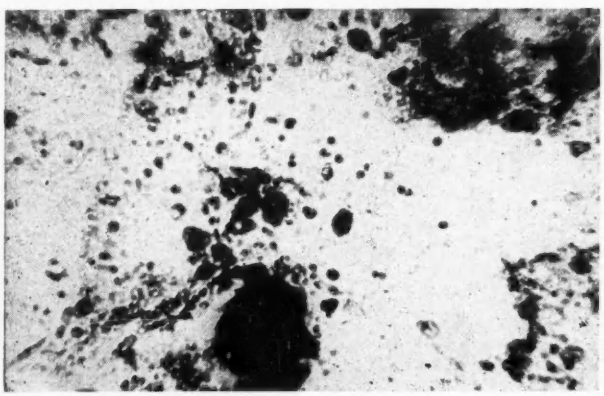
16. Cornstarch, Water—Color added



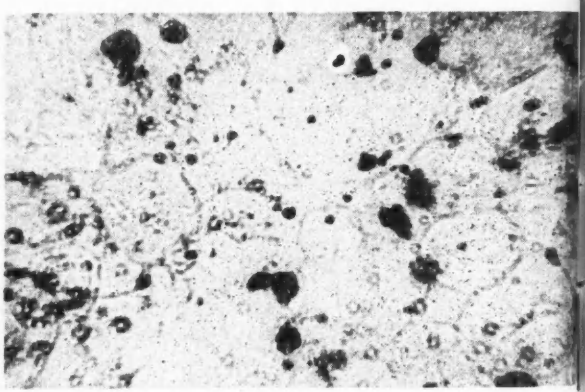
17. British Gum, Water—Color added



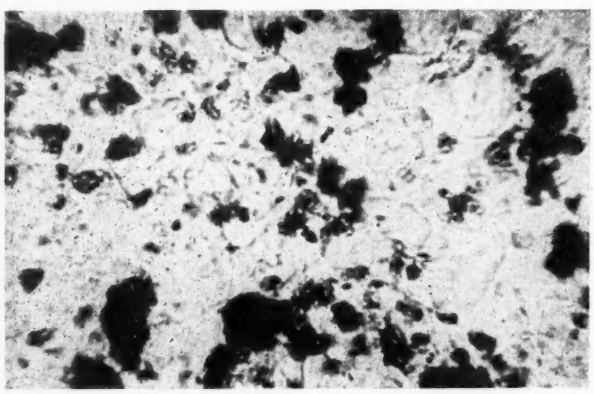
18. Cornstarch, British Gum, Water—Color added



19. Cornstarch, British Gum, Water, Sodium Carbonate—Color added



20. Cornstarch, British Gum, Water, 1% Glue—Color added



21. Cornstarch, British Gum, Water—Color with Water and .3% Glue added

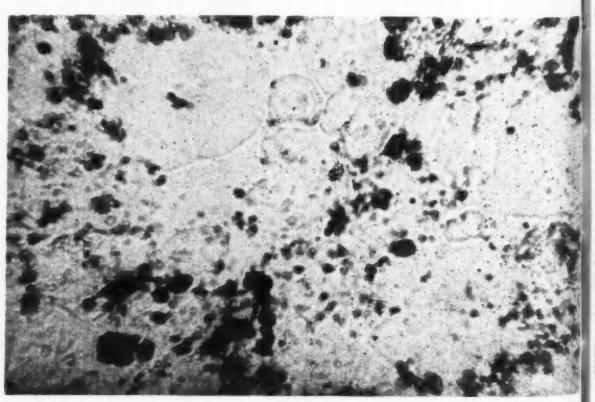
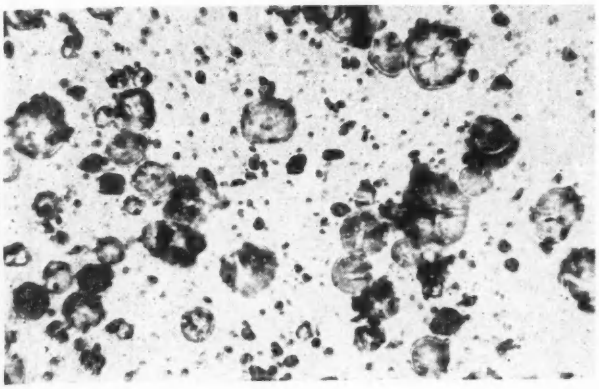


Plate IVb, Nos. 28, 29, 30, 31. Spectrophotometric charts of the pigment prints are shown on the plate of spectrophotometric charts. The dispersion and color yield improved as the particle size of the silica decreased.

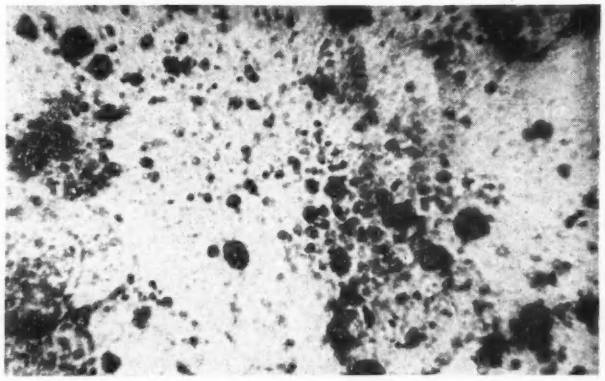
The preceding work with the inerts was simply to show their use in conjunction with a starch-British Gum paste as a pigment printing medium, so another experiment was made using the two types of calcium sulfate in conjunction with a vat printing paste which in addition to starch-British Gum thickener contained soda ash, sodium sulfoxylate formalde-

PLATE IVa
EFFECT OF PARTICLE SIZE

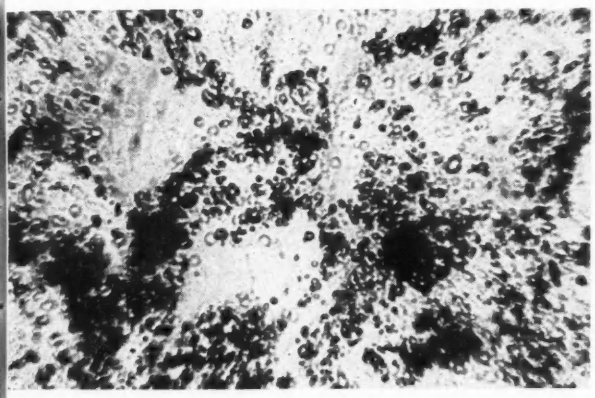
22. Cornstarch (Uncooked), Water, Color



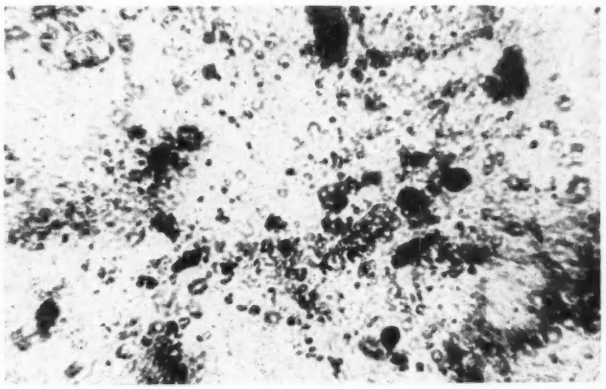
23. Cornstarch, British Gum, Water, Color



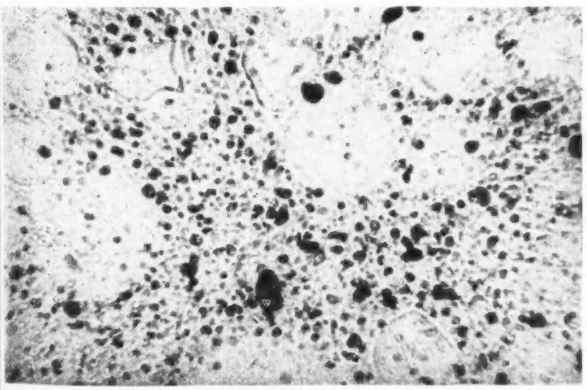
24. Cornstarch, British Gum, Water, Color, Aluminum Oxide 1-4 Microns



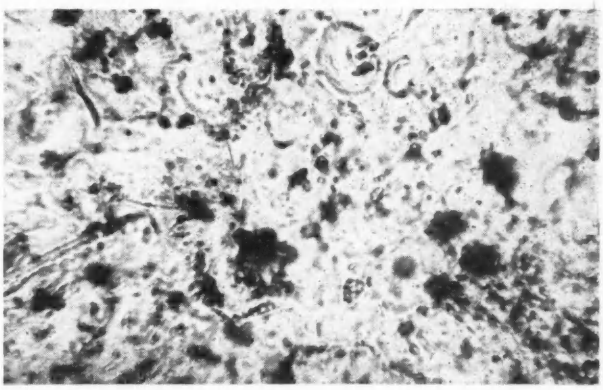
25. Cornstarch, British Gum, Water, Color, Aluminum Oxide 50-125 Microns



26. Cornstarch, British Gum, Water, Color, Bentonite 1-5 Microns



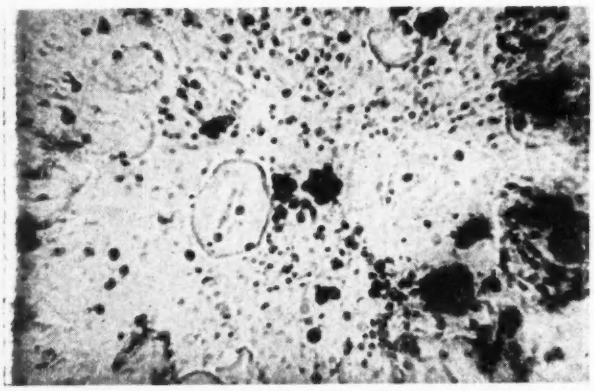
27. Cornstarch, British Gum, Water, Color, Diatomaceous Earth 1-60 Microns



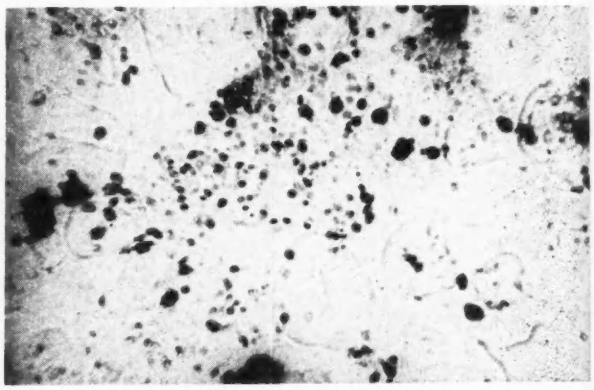
hyde and glycerine. Spectrophotometric charts of the paste, the pigment print and the developed print are shown on that plate. It is realized in using these two types of calcium sulfate that they have different crystal habit and different indices of refraction. In the pastes containing the calcium sulfate there was a marked contrast in appearance which is shown on the spectrophotometric chart. Where the average particle size was small, below that of the color, the paste was a pale blue indicating that the white particles of calcium sulfate had coated many of the color particles, and where the

PLATE IVb
EFFECT OF PARTICLE SIZE
Cornstarch, British Gum, Color Series

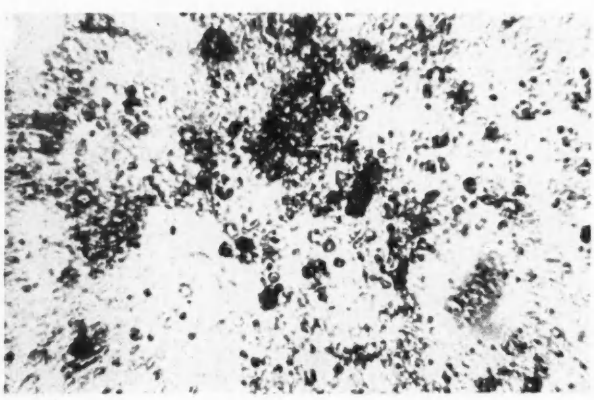
28. No Silica



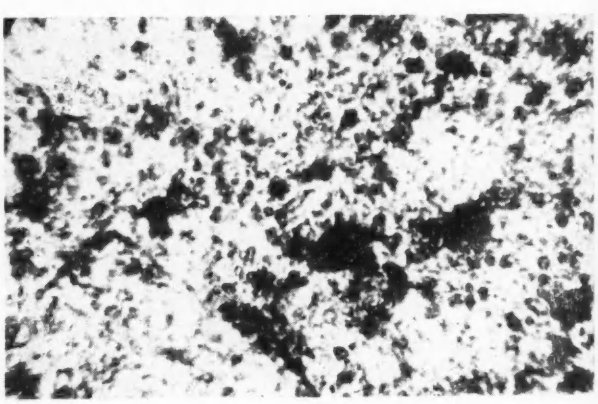
29. 5 Gms. Silica (Syton) under .5 Microns



30. 5 Gms. Micronized Silica 1-4 Microns



31. 5 Gms. Screened Silica 50-125 Microns



average particle size of the calcium sulfate was above that of the color, the color had coated many of the white particles so that the paste had an intense blue shade. This difference was also shown to a certain extent in the pigment print, but when the print was fully developed according to the practice with vat color prints, the difference was no longer evident.

CONCLUSION

From a practical standpoint these studies show that in the use of pigments, microscopic examination should be made to see if any agglomeration exists. If there is no evidence of any, or only slight traces, the dispersion might be improved by addition of finely divided particles of inerts, care being taken to see that such addition does not introduce harmful factors such as particles which would scratch a print roller.

If serious agglomeration exists, this work indicates that there are at least three factors which have been shown to cause agglomeration and investigation should be made to see if they exist and have caused agglomeration. They are:

1. Presence of electrolytes which affect the electrical charge on the pigment particle.
2. Presence of materials which affect the degree of hydration of the color particles.
3. The nature of the colloidal dispersion of the vehicle.

EXPERIMENTS

A. EFFECT OF ELECTROLYTYES—PLATE I

Water dispersions of color pastes were prepared in which 1% mono—, bi—, and trivalent cations were present as sodium chloride, calcium acetate and chromium acetate, respectively. The pH of each solution was adjusted to 6.0 with acetic acid or ammonia. In all cases 5 grams of color paste were added to 100 cc. of solution. As shown in Plate I agglomeration of the color particles becomes worse as the valence increases.

In Plate I, Photomicrographs Nos. 5 and 6 illustrate the effect of a trivalent negative ion versus a bivalent negative ion. In these dispersions 5 grams of vat color paste were added to 100 cc. of 1% solutions of sodium carbonate and trisodium phosphate. The trivalent phosphate ion caused increased agglomeration of the color particles.

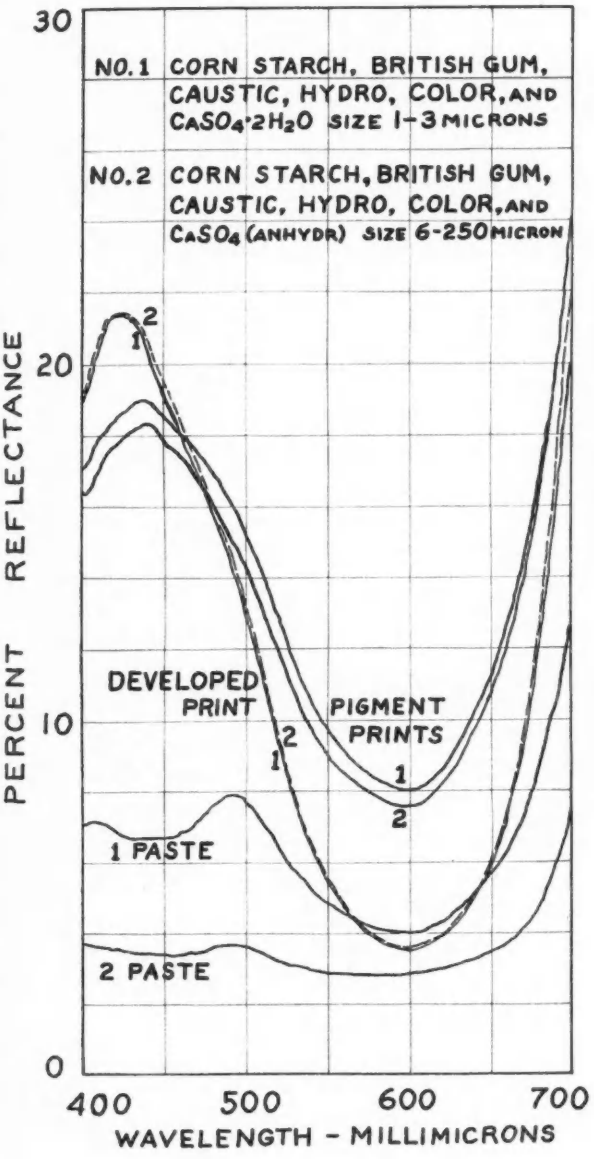
B. EFFECT OF HYDRATION OF COLOR PARTICLES—PLATE IIa

In Plate IIa the effect of dehydrating agents is observed, two reagents being studied. Anhydrous ethyl alcohol prepared by distillation from a saturated alcoholic solution of calcium oxide, and silica gel were used.

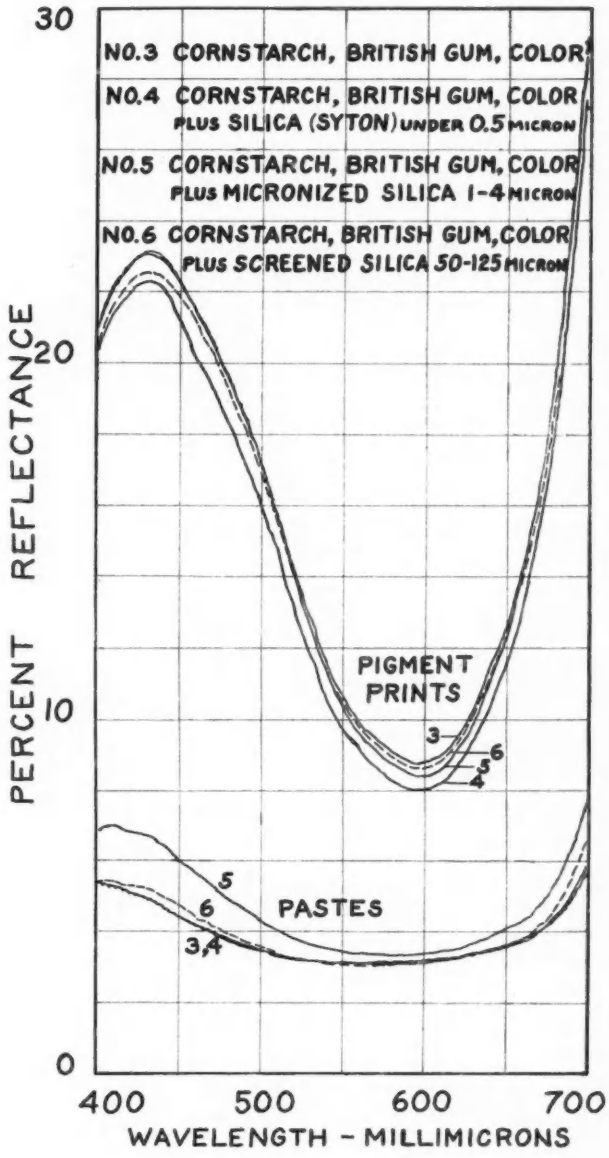
Using silica gel as the dehydrating agent 4 grams were added directly to 5 grams of vat color paste, stirred, and

SPECTROPHOTOMETRIC CURVES

CALCIUM SULFATE SERIES



SILICA SERIES



then mixed with 100 grams of a starch paste containing 8% corn starch and 12% British Gum. Photomicrograph No. 7 shows very bad agglomeration of the color particles presumably caused by the silica gel removing water from the protecting envelope around the color particle. Seventy-five grams of a corn starch-British Gum paste containing 8 grams corn starch and 12 grams British Gum was then prepared. Four grams of silica gel were mixed with 25 grams of water and this mixture stirred into the starch-British Gum paste. To this paste of starch-British Gum and silica gel were added 5 grams of vat color paste. No agglomeration beyond that obtained with starch-British Gum alone was observed as is illustrated in Photomicrograph No. 8. It seems quite evident that by allowing dehydrated silica gel to act directly on the water envelope of the color particle, its balance is upset, and agglomeration results, whereas by allowing the silica gel to become hydrated no adverse effect results. With anhydrous alcohol a similar effect was observed. In one experiment 10 grams of anhydrous alcohol were added to 5 grams of color paste and this mixture stirred into 100 cc. of water. The color particle showed considerable agglomeration. In a second experiment the same amount of anhydrous alcohol was added to water and the vat color paste stirred into the alcohol-water solution. No further agglomeration was observed.

C. EFFECT OF HYDRATION OF COLOR PARTICLES—PLATE IIb

A series of color pastes was prepared in which the same amount of starch paste was used in each instance. The same amount of water and vat color

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paste was used every time, the variation being whether the water was added to the color or to the starch paste. The pastes as prepared were as follows:

Photomicrograph Nos.	Grams of 5% Corn Starch Paste	Water Added To Starch Paste	Water Added To Dye	Grams Vat Color Paste
11	30	30	0	5
12	30	20	10	5
13	30	10	20	5
14	30	0	30	5

As the amount of water added to the vat color paste increased, agglomeration of the color particles decreased, but when the same amount of water was added to the starch paste and color then added, no reduction in agglomeration occurred. In Photomicrograph No. 15 no agglomeration is observed when uncooked corn starch, water and vat color paste are mixed. Therefore, if the color particles have sufficient water present before they are added to the starch paste the dehydrating action of the starch gel upon the water envelope appears to be overcome.

D. EFFECT OF COLLOIDAL STRUCTURE OF THE THICKENER

Pastes were prepared using different amounts of different thickeners so as to have pastes of approximately the same body. These were all cooked according to standard procedure except those using Bentonite and Methocel, which were prepared cold.

Four grams of vat color paste were added to 56 grams of each paste. The pastes were then examined between microscope slides for agglomeration and prints were made.

Pasts	Agglomeration	Strenth of Print (No. 1 strongest) (No. 7 weakest)
5% Corn Starch	All large agglomerates	6
40% British Gum	Very slight agglomerates	2
6% Alkaline Converted Starch	Very bad agglomerates	5
6% Tragacanth	No agglomerates	4
20% Karaya	No agglomerates	3
10% Bentonite	No agglomerates	1
3% Methocel 4000 Cps.	All agglomerated	7

This test shows that the thickener alone has very considerable effect upon the dispersion of the vat color pigment.

E. EFFECT OF ADDITION OF FINELY DIVIDED SOLIDS—PLATE IVa

This series of experiments covering Photomicrograph Nos. 22, 23, 24, 25, 26 and 27 was made to ascertain the effect of the addition of finely divided relatively inert solid materials in the systems studied.

In this series all of the pastes contained 8% corn starch and 12% British Gum with the exception of that shown in Photomicrograph No. 22 which contained an 8% uncooked corn starch suspension. No agglomerating effect on the color particles is seen in number 22. This fact illustrates the point that unless the starch granules are ruptured no agglomeration of the vat color particle occurs.

In order to study the effect of various finely divided solids several micronized products of different particle size were obtained, as follows:

Solid Material	Grade	Particle Size in Microns
Micronized Aluminum Oxide	Regular..	1–4
Micronized Aluminum Oxide	Screened.	50–125
Diatomaceous Earth	Regular..	1–65

In addition to these relatively inert materials, a Wyoming Bentonite was compared as a standard based on work by the Rhode Island Section Intersectional Contest Committee last year (1)*.

The experiments were prepared by pasting the starch-British Gum at 190-195°F. followed by addition of 5 grams of the solid material in a 25 cc. water slurry to the starch-British Gum paste. Five grams of vat color paste were then added, stirred thoroughly and examined under the microscope at 430 magnification. In the case of Bentonite a 50% water dispersion was prepared, the starch being pasted in a more concentrated batch in order that the final concentration of corn starch and British Gum would remain unchanged.

In every case the addition of a solid material, inert with respect to the system being studied, effectually prevented agglomeration of the color particle which factor was further substantiated by increased color yield when prints were made.

F. EFFECT OF ADDITION OF FINELY DIVIDED SOLIDS—PLATE IVb

In order to study the effect of varying the particle size of a given compound, a series of experiments was carried out using silica as the solid material added to the starch-British Gum paste.

In Photomicrographs Nos. 29, 30 and 31, 5 grams of silica as a slurry in 25 cc. of water ranging from .04 microns to 125 microns were added to a corn starch-British Gum paste containing 8% corn starch and 12% British Gum. The silicas used were as follows:

Grade	Particle Size in Microns
Colloidal Silica (Syton)	.04
Micronized Silica (Regular)	1–4
Micronized Silica (Screened)	50–125

After the silica slurry was stirred into the starch paste 5 grams of vat color paste were added and the dispersion observed under the microscope. Pigment prints of all the silica formulas were made. From visual observation and spectrophotometric curves it was found that color yield improved as the average particle size of the solid material decreased. Silica at .04 micron gave better color values than silica of 50-125 micron range. This fact substantiates visual observation with the microscope and is illustrated in Photomicrographs Nos. 29, 30 and 31.

* REFERENCES

1. Intersectional Contest Committee, Rhode Island Section—*American Dyestuff Reporter*—Vol. 33, No. 25, Page 502, Year 1944.
2. Hauser and Lynn—"Experiments in Colloid Chemistry,"—McGraw-Hill Book Company, Inc., Pages 110 and 111.
3. IBID—Page 64, Experiment 66.

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Whittaker, Clark and Daniels, Inc.

* Figures in parentheses refer to references at end of paper.

Intersectional Contest—☆ Second Prize ☆

THE MECHANICS OF ZONE CONTROL IN RESIN FINISHING*

Presented by the
NORTHERN NEW ENGLAND SECTION

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FOREMOST of the interesting and useful features of the modern rapid development of resin finishing are the striking and valuable contrasts in properties of the finished textiles obtainable by controlling the zoning of the resin finish either within, or around and "on" the textiles fibers. The two extremes of such zoning are: (1), when the resin is distributed uniformly "in" or throughout the whole fiber; and (2), when the resin is restricted to a limited zone of the treated fiber, as, for example, an exterior sheath of resin "on" and around the fiber: (See Figures I, II, and III.)

Consider the three basic classes of resin finishing: (A), when the completely presynthesized resin is applied either from emulsion or solution, and no "curing" or increase in molecular complexity of the resin is feasible or desirable during the finishing process; (B), when the resin substrate (first-stage, or partially condensed or partially polymerized resin) is applied in relatively low molecular weight condition to the textile, and "curing," with attendant very great increase in molecular complexity is effected, in situ, during the finishing process, usually by heat and catalysts; and (C), when the monomer, usually a "thin" oil, is applied together with dissolved catalyst, and polymerization, or complete synthesis of the resin, is then carried out, in situ, by heating. A specific example for each class is: (A), polyvinyl acetate emulsion; (B), urea and melamine resins; and (C), di allyl phthalate.

From first principles, only the "on," or exterior sheath type of zoning is feasible by (A) class materials, the extreme molecular complexity and consequent lack of diffusibility of the presynthesized resin precluding any penetration into the fiber. With (B) and (C) class materials, on the other hand, the low molecular weight and consequent diffusibility, with attendant ability of the initial resin substrate to penetrate the fiber, offer the textile technologist fascinating vistas of radically varying effects, even with the same resin, yielded by suitable control with specialized technique during the finishing process. Practically, among the commercially available resins, (B) class materials are being the most intensively explored although (C) class products are distinctly above the horizon and more and more engaging the efforts of the major producers.

A periscope glimpse into the future sights ever more useful and versatile resin finishes to come, where the great advantages bound to accrue from perfected zone control of (B) and (C) class products are supplemented by firm chemical anchorage of resin to textile base material (for example, cellulose) by some such primary valence union as that now being obtained with certain diisocyanates, for example. Resubmerging into 1945, there has been undertaken some exploration of zoning of (B) class products,

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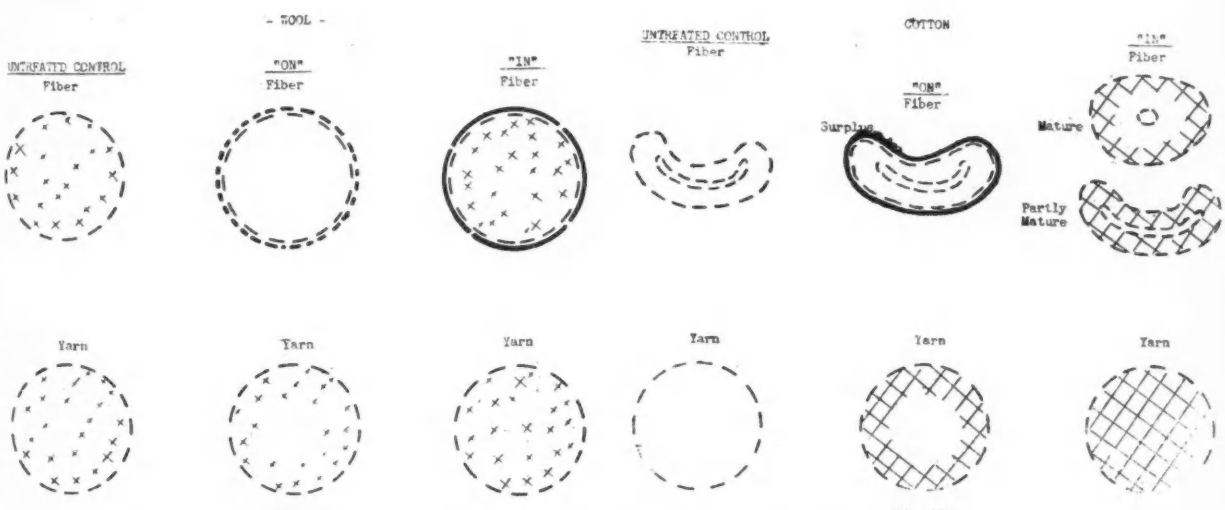


Fig. I
Diagrams of Cross Sections of Fibers and Yarns Illustrating Distribution of Resin. Outlines of Cross Sections in Broken Lines. Outer Broken Lines Indicate Resin. Cross Hatching Indicates the Extremely Irregular Distribution of Dye.

Fig. II
Diagrams of Cross Sections of Fibers and Yarns Illustrating Distribution of Resin. Outlines of Cross Sections in Broken Lines with Full Lines Outside Indicating Exterior Resin Sheath. Cross Hatching Indicates Resin Penetration.

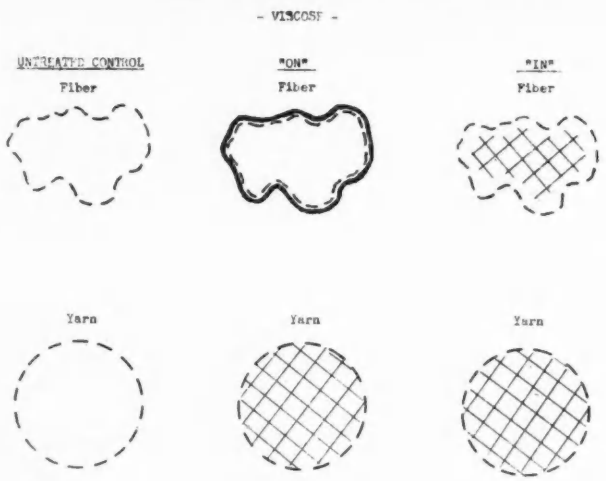


Fig. III
Diagrams of Cross Sections of Fibers and Yarns Illustrating Distribution of Resin. Outlines of Cross Sections in Broken Lines with Full Lines Indicating Exterior Resin Sheath. Cross Hatching Indicates Resin Penetration.

especially melamine-formaldehyde resins, on wool, cotton and rayon.

Toward firm conclusions that the differences in physical properties of the finished textiles, about to be presented, are due, simply and solely, to zoning, the same resin substrate (methylol melamine, with an average of 2.3 methylol groups per melamine ring) in the same concentration (10%) was used throughout, with identical curing catalyst (zinc chloride) in the same proportion (1.5%, based upon resin solids) and the same time and temperature of curing. The only variation was that water was the solvent and fluid treating medium where "in" zoning was desired, while aqueous ethyl alcohol was used where "on" zoning was desired.

In no case was any attempt made to get the extremes in specific effects such as are obtained, industrially, by much higher resin concentrations. The measurements, on the other hand, covered the wider range necessary to present a comprehensive survey of how the various physical properties of textiles are affected by zoning. No attempt is made to delve into the multiplicity of physical and chemical reasons underlying the fact that watery media tend, with methylol melamines, toward "in" zoning, while alcoholic media tend toward "on" zoning; this was applied merely as a tool to obtain "in" and "on" zoning, the existence of which was first clearly demonstrated by microscopic examination of the finished textiles.

Results indicate that many differences in physical properties of the treated textiles are entirely consistent with the corresponding differences in zoning shown independently by the microscope.

The ten percent water solution of methylol melamine used for the "in" treatments was prepared readily by "whipping in" the powdered resin substrate at room temperature with high speed agitation; the requisite amount of 27% zinc chloride solution was then stirred in just prior to the fabric treatment, which was carried out at room temperature in a laboratory padder. The fabric, first completely desized and then thoroughly extracted with carbon tetrachloride and finally air dried, was padded to yield a wet "pickup" of 60% plus or minus 5%; after air drying, on horizontal wire frames, the "curing" was accomplished by suspending in an air oven regulated at 275°F. for five minutes. To remove zinc chloride and possible acidic by-products, the cured fabric was thoroughly laundered under mild conditions, then dried and ironed.

The ten percent aqueous alcoholic solution of methylol melamine for the "on" treatments was prepared by first dissolving the powdered resin substrate in water to yield a 30% solution which was then diluted with two volumes of denatured ethyl alcohol ("Solox"). One percent of glacial acetic acid was then stirred in, and then the requisite amount of 27% zinc chloride solution. Padding and subsequent curing, washing, drying and ironing were done just as for the "in" treatment.

Since some shrinkage and other minor dimensional derangement of fabric is inevitable during padding, curing, washing and ironing, "control" fabrics were prepared by putting them through the entire cycle just as outlined but using water instead of resin substrate solution. Variation in physical properties between the treated and "control" fabric is, therefore, strictly due to resin.

First, direct visual evidence of zoning was obtained by staining and microscopic examination, the staining medium, Anthraquinone Blue BN, being applied from dilute acetic solution under conditions where the acid nature of the dye would tend to accent the color in approximate proportion to the amount of resin present. Chemically, this is very conventionally accounted for by the multiplicity of amino and imino groups present in the cured melamine resin which certainly would tend to retain the acidic dyestuff more tenaciously than would plain cellulose containing no melamine resin, and, also chemically, it is obvious why unsatisfactory contrasts were obtained with a polyamide such as wool where the textile base material itself contains a multiplicity of basic imino groups. (See Figure I.)

Small pieces of the respective resin treated fabrics, together with untreated controls, were dyed at room temperature for about four hours in a 0.25% water solution of Anthraquinone Blue BN, with one drop of glacial acetic acid added to each c.c. of the dye solution. The dyed fabrics were then removed from the dye solution and were washed in several changes of warm water until the untreated cotton and viscose were entirely decolorized. Thus, any resin present "in" or "on" the cotton and rayon was readily observable, in that the resin dyed while the cellulose did not. In the case of wool, the Anthraquinone Blue BN, being an acid dyestuff, dyed the wool as well as the resin. Only for the "on" treatment was there a difference in hue or intensity; hence, resin distribution was observable only to a limited extent.

The fabrics were then dried, imbedded in a xylol solution of poly-isobutyl methacrylate, sectioned, mounted in mineral oil (Texaco 300) and examined at various magnifications up to 400 diameters. It is not maintained that the distribution of dye color so obtained necessarily gives a one-hundred percent precise picture of the resin distribution, but it probably does give a reasonably satisfactory picture. The alternative of doing several hundred micro-Kjehldahl analyses would indeed have been an Herculean task.

In the table of results, (Table I) the "in" and "on" distributions were examined microscopically as regards the yarns as units, and also as regards the individual

TABLE I
Distribution of Dyestuff

Fabric	Treatment	Yarn Penetration	Yarn Distribution	Fiber Penetration	Fiber Distribution
WOOL	None	Throughout	Irregular	Irregular	No exterior sheath; some in interior
	"ON"	Outer half diameter	Irregular; none in center	None	Irregular exterior sheath, with discrete particles
	"IN"	Throughout	Irregular	Irregular	Irregular exterior and interior
COTTON	None	None	None	None	None
	"ON"	Irregular	Outer half diameter	Very Little	Thin exterior sheath
	"IN"	Complete	Uniformly throughout	Throughout	No exterior sheath; Completely through immature fibers, partly through mature fibers
VISCOSE	None	None	None	None	None
	"ON"	Partial	Irregular	None	Continuous thin exterior sheath
	"IN"	Complete	Uniformly throughout	Complete	No exterior sheath; much within fiber

While these results are indicative but not conclusive for wool, for the chemical reason previously mentioned, they are indeed conclusive for the two cellulosic fabrics.

fibers as units.

The efficacy of shrinkage control by the application of methylol melamine solution to wool fabrics and cellulosic fabrics is already well established. It is the purpose of this investigation to study their effects upon other important physical properties which may be governing criteria in end use.

The following properties were determined:

Fabric Count	Stiffness
Strength	Resilience (Compressional)
Elongation	Dimensional Stability
Thickness	Thermal Transmission
Air Premeability	Shrinkage

FABRIC COUNT
(See Table II

TABLE II
Yarns Per Inch

Fabric	Warp	Filling
Wool Control	62.5	50.0
Wool "ON"	64.5	51.0
Wool "IN"	65.0	50.5
Cotton Control	68.4	51.4
Cotton "ON"	69.0	51.2
Cotton "IN"	69.8	51.4
Rayon Control	67.8	45.8
Rayon "ON"	68.6	42.6
Rayon "IN"	69.2	43.6

See Graph I

Application of the resin, either "in" or "on," creates no essential dimensional aberrations when compared with the control fabric. Thus, it may be concluded that differences in physical properties discussed below are simply and solely due to zoning.

STRENGTH AND ELONGATION
(See Tables III and IV)

The strength of the wool fabric is not affected materially by the treatments both warp and fillingwise. This may be attributed to two major factors: 1—The acid catalyst used in curing the resin has no tendering effect on the wool; 2—Variations in length of yarn and fabric components due to twist, crimp and weaving tensions produce the well-known "serigraph effect" and tend to reduce the ultimate strength of the material. This serigraph effect is less pronounced in high extension structures, since the various components have greater opportunity for relative adjustment.

Application of resin, either "in" or "on" the wool, would tend to decrease the extension, increase the serigraph effect and thereby decrease the strength. However, the extensibility of the wool is so great that the resin under the conditions of application, has but a negligible restraining effect percentagewise. Thus, the strength is not materially diminished.

In the case of the cotton and the rayon, the same two factors prevail. The acid catalyst tenders the cotton and rayon and reduces the strength. If this were the only prevailing factor, it would be expected that both the "in" and "on" treated fabrics would suffer equally. The elongations of the cotton and rayon controls are less than those of the wool. therefore, the serigraph effect should be more pronounced, The "on" treatments diminish the elongation more than do the "in" treatments; hence, the "on" strengths are lower than the "in" strengths independent of any chemical tendering.

The data confirm this reasoning in each instance except for the cotton filling, where the extension of the control appears to be anomalously low.

The "on" treatment creates a relatively continuous sheath *around* the fibers while the "in" treatment results in a multiplicity of discrete particles *within* the fibers. Thus, the greater reduction in elongation of "on" fabrics can be attributed to this difference in resin distribution.

THICKNESS
(See Table V)

TABLE V
Thickness
(Inches)

Fabric	Wool	Cotton	Rayon
Control	.0265	.0125	.0140
"On"	.0313	.0131	.0151
"In"	.0302	.0121	.0146

See Graph IV

For the various fabrics, the thickness of the "on" is significantly greater than the control.

For the wool, the "in" is significantly thicker than the control, while in the case of the rayon and cotton, the control and the "in" show no significant differences.

Comparison of "on" with "in" indicates a significant difference for wool and cotton but not for rayon.

AIR PERMEABILITY
(See Table VI)

TABLE VI
Air Permeability
(Cu. Ft./Min./Sq. Ft.)
At 0.5" Water

Fabric	Wool	Cotton	Rayon
Control	165	154	202
"On"	137	120	177
"In"	171	138	215

There is no significant difference between the control and the "in" for Wool, Cotton, or Rayon, while the "on" treatment yields a significant reduction in air

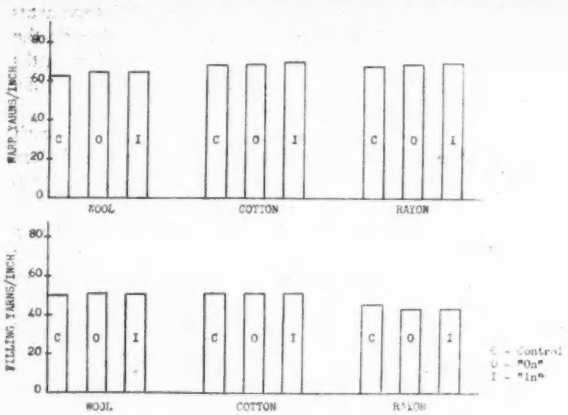
TABLE III
Strength
(Pounds)

Fabric	Wool Warp	Wool Filling	Cotton Warp	Cotton Filling	Rayon Warp	Rayon Filling
Control	28.2	27.6	46.8	22.2	42.4	55.6
"On"	29.0	24.6	34.0	11.1	24.3	39.3
"In"	27.9	26.3	39.0	18.4	44.4	47.7

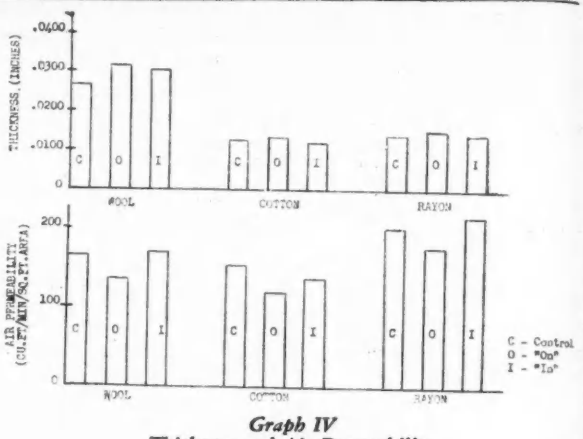
TABLE IV
Elongation
(Percent)

Fabric	Wool Warp	Wool Filling	Cotton Warp	Cotton Filling	Rayon Warp	Rayon Filling
Control	30.0	36.2	7.9	16.3	13.9	9.8
"On"	27.2	34.5	4.5	17.7	7.3	5.4
"In"	27.5	38.1	7.0	20.1	15.4	8.9

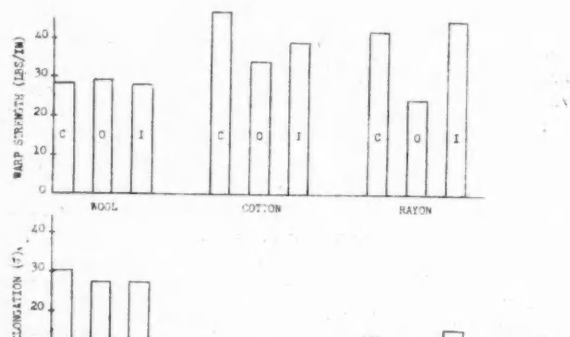
See Graphs II and III



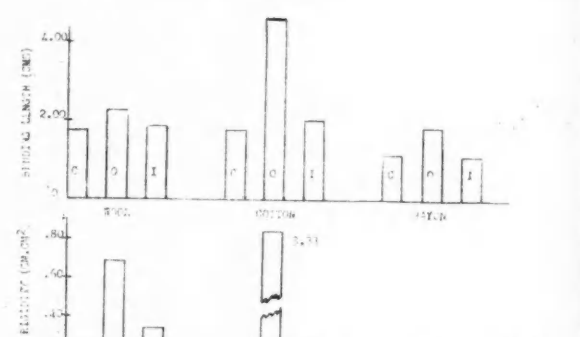
Graph I
Fabric Count



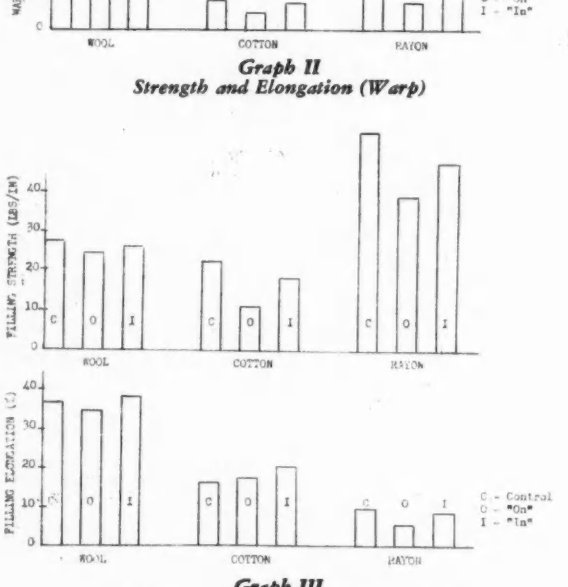
Graph IV
Thickness and Air Permeability



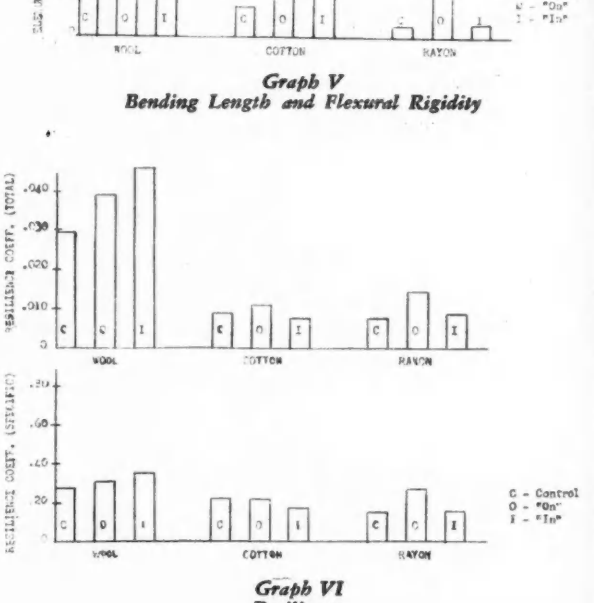
Graph II
Strength and Elongation (Warp)



Graph V
Bending Length and Flexural Rigidity



Graph III
Strength and Elongation (Filling)



Graph VI
Resilience

permeability in every case. The "on" and "in" are significantly different for the three fabrics.

The increased thickness of the "on" samples compared to the controls undoubtedly is accompanied by a restriction of the interstices, and this restriction, coupled with an increase in length of path through which the air must pass, gives rise to the decrease in permeability. By the same reasoning, the wool "in" being thicker than its control *should* have a lower permeability. The fact it does not is an apparent anomaly. In the case of cotton and rayon, no significant

differences in thickness exist between the control and the "in" which correlates well with the air permeability data shown above. Correlation with thickness exists for the "on" and "in" for wool and cotton, but not for rayon.

It must be remembered that thickness is not the only controlling factor affecting permeability. Hence, the lack of perfect correlation between air permeability and thickness is to be expected.

STIFFNESS

(See Tables VII and VIII)

TABLE VII
Bending Length
(Cms)

Fabric	Wool	Cotton	Rayon
Control	1.73	1.80	1.18
"On"	2.28	4.67	1.89
"In"	1.89	2.06	1.19

TABLE VIII
Flexural Rigidity
($GmCm^2$)

Fabric	Wool	Cotton	Rayon
Control	.24	.15	.06
"On"	.68	3.33	.28
"In"	.34	.24	.07

See Graph V

Bending length may be considered to be an indication of the draping qualities of a material, while flexural rigidity is a measure of resistance to bending. High values indicate poorer draping qualities and greater stiffness.

For both bending length and flexural rigidity, appreciably higher values are indicated for the "on" treatment. The "in" treatment shows an increase over the control but to a substantially lesser degree.

The melamine resin is more rigid than wool or cellulose, and stiffer fabrics would be expected when applied either "in" or "on." In the "in" samples, the resin is distributed in discrete particles, and some increase in stiffness results. For the "on" fabrics, the resin consists of a continuous exterior sheath; here, it acts as a structural unit and greatly increases the stiffness.

RESILIENCE

(See Tables IX and X)

TABLE IX
Total Resilience Coefficient
(In./Lb.)

Fabric	Wool	Cotton	Rayon
Control	.0293	.00688	.00717
"On"	.0392	.0108	.0144
"In"	.0462	.00742	.00859

TABLE X
Specific Resilience Coefficient
(In./In./Lb.)

Fabric	Wool	Cotton	Rayon
Control	.270	.217	.151
"On"	.307	.215	.276
"In"	.347	.177	.156

See Graph VI

Compressional resilience may be defined as the ability of a structure to absorb and return energy under repeated stress application. Two criteria may be employed: 1—Total Resilience, which expresses this energy absorption capacity on a basis of total thickness; and 2—Specific Resilience, which expresses the energy absorption capacity on a unit thickness basis.

It has been demonstrated that, all other factors being equal, greater energy absorption capacities exist where low average moduli of elasticity prevail. It should be pointed out that the resilience properties as measured in this study, depict the properties of the entire fabric structure and not the inherent properties alone of the materials comprising them. Thus, it is possible to increase the average modulus and recoverability of the fibers, by the addition of a medium of greater rigidity such as the melamine resin, and at the same time maintain a relatively low modulus in the fabric as a whole.

This is analagous to the coiled wire spring, where the modulus of the material from which it is fabricated may be extremely high and that of the spring itself sufficiently low to yield a high energy absorption capacity per unit load far in excess of that of the wire itself. A similar wire spring constructed from a wire of lower modulus would yield an even greater energy absorption capacity.

The compressional resilience of a fabric structure reflects the performance of its components which act much in the same manner as the springs described above. The addition of the resin increases the rigidity of these components and, at the same time, tends to improve the recoverability.

In the case of the wool, both the "in" and the "on" treatments show an improvement over the control, the "in" being preferred. Microscopic examination of the wool fibers indicates a greater tendency to the existence of a continuous outer sheath in the case of the "in" than the "on" (see FIG. I) and this, coupled with the presence of resin within the fibers may account for the greater improvement in resilience of the "in" samples. The poorer original resilience properties of the cotton and rayon are not as greatly improved as are the better original resilience properties of the wool.

Cotton is notoriously poor in resilience and has a high modulus of elasticity. The rigidity of the structural units is increased by resin application, but the modulus and recoverability of the entire fabric structure, while improved in the case of the "in" and "on" treatments, is not comparable with that of the wool fabric. The additional rigidity due to sheath effect (See Fig. II) accounts for the preferred resilience properties in the case of the "on" treatment.

Similarly for Rayon reference to Fig. III indicates preferred properties for the "on" treatment.

DIMENSIONAL STABILITY

(See Table XI)

TABLE XI
Bulk Factor
(% of Orig. Thickness)

Fabric	Wool	Cotton	Rayon
Control	.851	.851	.821
"On"	.902	.817	.879
"In"	.908	.804	.857

See Graph VII

Bulk Factor indicates the ability of the fabric to retain its original geometric structure after repeated compressional stress application. It is the ratio of the fabric thickness under a 0.1 lb. load at the start of the first loading cycle and the thickness under the same load at the start of the fifth loading cycle.

Since bulk factor is a ratio of thickness it is a specific property. Comparison with specific resilience coefficients (see Graph VI) indicates perfect rank correlation.

THERMAL TRANSMISSION

(See Tables XII and XIII)

TABLE XII
Thermal Conductance C
(cals/sq M/sec/°C)

Fabric	Wool	Cotton	Rayon
Control	10.92	16.03	16.62
"On"	10.79	14.52	15.73
"In"	10.63	17.12	16.14

TABLE XIII
Specific Coefficient of Conductivity K
(cals/sq M/sec/°C/CM)

Fabric	Wool	Cotton	Rayon
Control	0.73	0.51	0.62
"On"	0.86	0.48	0.61
"In"	0.82	0.52	0.62

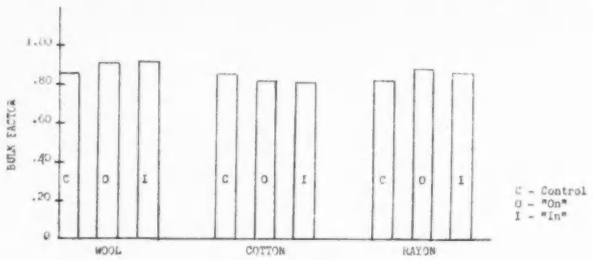
See Graph VIII

There are two criteria of insulation: Conductance, C, and Specific Coefficient of Conductivity, K.

Conductance, C, is the absolute measure of heat flow thru the specimen for the thickness of the particular sample being investigated. It indicates the total insulation abilities of the fabrics as the fabrics exist. per se. Coefficient of Conductivity, K, is the specific index of insulation and indicates the inherent insulation ability of the material per unit thickness.

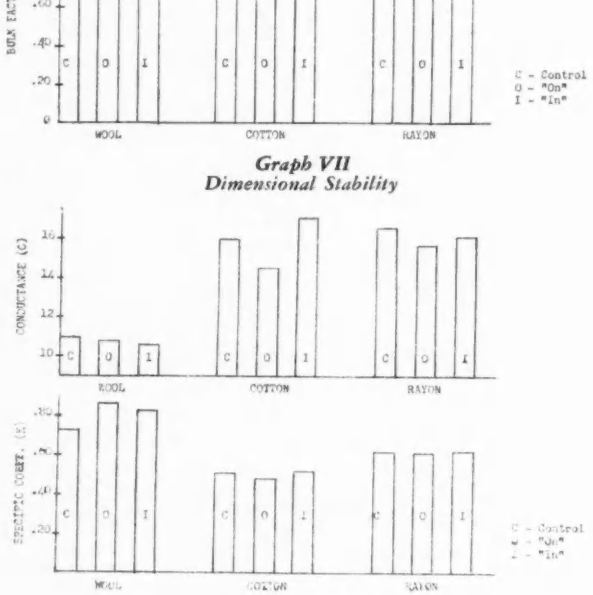
The higher the Conductance, C, the poorer is the heat insulating ability of the material. Similarly the higher the value for the Coefficient of Conductivity, K, the poorer is the insulator.

Analysis of Conductance, C, values shows wool to be very slightly improved by both "in" and "on" treatments. For cotton the "on" treatment creates an appreciably better insulator; the "in" treatment is poorer than the control. Rayon evidences a lower conductance for both



Graph VII
Dimensional Stability

Graph IX
Volumetric Shrinkage



Graph VIII
Thermal Transmission

"on" and "in," the effect being greater for the "on."

Analysis of Coefficient of Specific Conductivity, K, data shows that for the wool both the "in" and the "on" are inherently poorer insulators than the control. The cotton and rayon show no essential improvement for the "on" and the "in" compared with the control, the "on" being preferred in each case. Reference to the K portion of Graph VIII shows that the wool fabrics in each case have poorer inherent heat insulation ability (respectively) than do the two cellulose counterparts. Reference to the C portion of Graph VIII shows the wool fabrics (respectively) to be much better total insulators than their cellulose counterparts. This is only because the wool fabrics are thicker, not because they are inherently better.

Comparison shows that lower values of conductance are correlated with higher values of thickness, See Graphs IV and VIII). Thus, it is quite evident that application of resin either "in" or "on," to the wool, cotton, or rayon does not make these fabrics better inherent insulators. Application does make them thicker, and because they are thicker, their total insulation ability increases.

It is a well recognized fact that thermal transmission properties are mainly governed by the degree and amount of entrapment of air. Therefore, it would be expected that the "on" fabrics would have lower conductance values since the application of the resin "on" the structure tends to make the fabrics porous rather than permeable. Hence, a direct correlation exists between lower conductances and lower air permeabilities. (Compare Air Permeability Graph IV with Conductance C Graph VIII.)

Since both air permeability and conductance were measured on the fabrics as they existed per se, the comparison of air permeability with specific conductivity K is not justified.

SHRINKAGE

(See Table XIV)

TABLE XIV
Volumetric Shrinkage
(% Gain in Wt./Sq. Yd.)

Fabric	*Wool*	*Cotton*	*Rayon*
Control	137	1.5	9.0
"On"	48	0.0	4.0
"In"	105	0.3	0.0

See Graph IX

As a measure of shrinkage, the weight in ounces per square yard before and after laundering was determined. Any gain in weight is a measure of volumetric shrinkage; that is, an aggregate effect of warp shrinkage, filling shrinkage and density change. It also reflects the resistance of the fabric to fulling and felting. The greater the percent gain in weight, the greater is the overall shrinkage.

For the wool, both "on" and "in" treatments appreciably reduce shrinkage—the "on" showing great improvement. In the case of the cotton, the control does not shrink appreciably; hence, neither the "in" or "on" treatment has an opportunity to be effective. For the rayon, the "on" shows some improvement, the "in" giving excellent results.

Examination of Figs. I, II, and III aids in interpreting the above results. The wool "on" treatment sheaths the yarns and fibers, the scales become less effective, the fiber becomes more rigid and tends to curl less. Felting is thus restricted and shrinkage is reduced. The sheath, being hydrophobic, prevents the fibers and yarns from wetting out, in turn inhibiting felting and shrinking.

The wool "in" treatment causes some shrinkproofing probably because a limited amount of resin is deposited on the yarn periphery and on some of the fibers.

In the case of the cotton, the shrinkage, as has been stated, is so small for the control that the treatments have no opportunity to prove themselves.

Why the rayon "in" should act more efficiently than the rayon "on" is not explainable and is apparently another anomoly. The resin sheath "on" the rayon yarn and fiber again possibly prevents the fibers from becoming wet. Thus, radial swelling with accompanying longitudinal contraction and shrinkage is inhibited.

* * *

From the foregoing analysis, it is apparent that the application of methylol melamine resin on fabrics of wool, cotton, and rayon definitely modifies other important physical properties. The tests carried out in this investigation are based upon randomly selected samples from

commercially available piece goods. Unfortunately, time permitted only one set of data for each fabric and, hence, the results and conclusions should be considered in the light of the fact. It is earnestly hoped that further investigation of the physical properties as they are affected by resin application will be stimulated by this study.

The author expresses his appreciation to Mrs. Robert H. Butler and Mrs. Benjamin H. Landing, Jr. of the Fabric Research Laboratories, Inc. for laboratory procedure and compilation of data and to Miss Anita Dori of the Slater Memorial Laboratory, Textile Division, Massachusetts Institute of Technology, for conducting the resilience tests.

TEST METHODS

Picks and Ends Per Inch

Picks and ends per inch were determined for the rayon and cotton fabrics by means of a Suter pick counter. Because of the nap on the woolen fabric, the pick counter could not distinguish individual yarns; therefore, picks and ends on this fabric were determined by marking off one-inch widths, unraveling, and counting yarns.

Thickness

Thickness, determined by means of a Randall-Stickney thickness gage, was measured under a 0.7-ounce dead weight and a ⅜-inch diameter presser foot.

Air Permeability

Air permeability was measured on the Frazier permeometer. The number of cubic feet of air per minute passing through one square foot of fabric was determined when the pressure drop across the fabric was equal to 0.5 inches of water.

Breaking Strength and Percent Elongation

Breaking strengths and percent elongations were determined according to the conventional American Society of Testing Materials ravel strip method. 6"x1¼" strips of the untreated fabrics were raveled to one inch and the number of yarns in the one-inch strip counted, after which they were broken on the testing machine. All treated counterparts were raveled to the same *number of yarns* regardless of whether or not a one-inch strip resulted. By breaking the same number of yarns, a direct comparison of breaking strength was obtained, unprejudiced by possible shrinking or stretching.

The specimens were broken on a 100-pound capacity Suter pendulum type tester wherein the gage length was three inches and the pulling jaw speed was 12 inches/minute. An autographic attachment plotted elongation.

Heat Conductivity

Heat Conductivity was determined by means of the Cenco-Fitch heat-transmission apparatus. The apparatus comprises a source of heat at constant temperature (212°F.) in contact with a layer of the material under test, and on the other side of the layer, a metal receiver block of known thermal capacity. The receiver is provided with a thermocouple connected in series with another thermocouple always kept at a constant temperature of 70°F., both being connected to a potentiometer. At the start of the test the receiving block is at the same temperature as the 70°F. reference thermocouple; thus no current flows and no galvanometer deflection results. The heat source is kept at 212°F. by means of boiling water. As the heat flows from the hot source through the fabric into the metal receiving block, the block heats up, resulting in a temperature differential between it and the 70°F. reference thermocouple. A corresponding current flow is indicated by the potentiometer. A plot of potentiometer readings vs. time is prepared which indicates the rate at which the lower block heats up, in turn indicating the rate a twhich heat is passing through the test specimen. Proper calibration allows potentiometer readings to be converted to receiver block temperatures. Knowing the temperature of the lower block at the start of the test, its rate of rise in temperature, its specific heat, its mass, and its area, the number of calories per unit area per unit time received by the block may be calculated. All of these calories necessarily passed through the fabric. A measure of the insulation ability of the fabric is thus obtained; for the less the heat flow through the fabric per unit time, the better is the insulation. Two criteria of insulation are obtained: Conductance, C, and Coeffiecient of Conductivity, K.

Conductance, C, is the absolute measure of heat flow through the specimen expressed in calories per square meter per second per degree Centigrade temperature differential for the thickness of the particular sample being investigated. It indicates the *total insulation ability* of the fabric as the fabric exists per se.

Coefficient of Conductivity, K, is the specific index of insulation and indicates the *inherent insulation ability* of the material per unit thickness. Its units are calories per square meter per second per degree Centigrade temperature differential per centimeter (thickness).

Summarizing, it follows that the higher the Conductance, C, the poorer is the heat insulating property of the material. Similarly, the higher the value for the Coefficient of Conductivity, K, the poorer is the insulator.

Resilience

Resilience was determined on the M.I.T. electronic resilience tester. By means of this instrument, cyclical loading and unloading of the specimen was accomplished, yielding automatically plotted graphs of load vs. compressional deformation.

The apparatus comprises a platform connected to an electric strain gage for recording load. The fabric is mounted on the platform. A plunger with a circular foot of one square inch area, and traveling at constant rate of 0.025 inches per minute is applied to the top of the fabric. Loads resulting from penetration of the plunger into the fabric are automatically recorded by means of the electric strain gage and a recording milliammeter. The plunger is allowed to penetrate into the fabric until a selected maximum load is obtained. Then the plunger direction is reversed and it is withdrawn from the fabric at the same rate, corresponding decreases in load being recorded. The resulting load-deflection graph may be utilized to calculate quantitative measures of resilience.

Shrinkage

Wash tests were carried out according to A.A.T.C.C. test methods. 30x6-inch samples were washed in a horizontal reversing type washing machine wherein the axis of the reversing agitator was vertical. Cotton samples were washed five times according to the recommended procedure at 212°F.; rayon samples were washed five times at 100°F. The woolen samples were washed five times at 100°F., after which they were washed three more times in a commercial laundry wheel at 100°F. with a full load to produce greater fulling action.

Shrinkage was determined on a three dimensional basis by calculating the weight of the fabrics in ounces per square yard before and after the above described washing procedure.

Stiffness

Two criteria of stiffness were calculated: bending length and flexural rigidity. A 6-inch by 1-inch sample was clamped at one end so that the long dimension was free to bend. The clamped sample was placed in a horizontal position and the angular deflection from the horizontal plane measured. The stiffer the fabric, the greater is the specimen length required to produce a unit angle of bend. Bending length is defined as the length necessary to bend the specimen through such a unit angle. Flexural rigidity may be broadly defined as the resistance to bending. High values of bending length and flexural rigidity indicate stiff materials.

Intersectional Contest ☆ Third Prize ☆

EVALUATION OF FABRICS AS TO THEIR FLAMMABILITY*

Presented by the

NEW YORK SECTION

COMMITTEE
New York Section
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Paper Presented By
CHARLES W. DORN

EVERYONE knows that the ordinary garments which we wear will burn. They are combustible. It is also well known that all garments do not burn with equal rapidity. Thus, wool and silken fabrics will hardly burn at all. In fact the fibers melt and in so doing prevent the ready access of air and the transmission of enough heat to cause rapid combustion. In the case of cellulosic materials, on the other hand, burning takes place more easily. Thus in cotton, linen, ramie, regenerated cellulose rayons, etc. fabrics, the fibers do not melt but become ignited, and depending upon the fabric construction, will burn rapidly or slowly. For example, those fabrics which have the individual fibers exposed as in a pile, or as tufts in chenille, or as in the loosely matted or brushed out fabrics, where there is a ready access of air around the individual fibers, are easily ignited, flame up and burn rapidly. But densely knit or woven cellulosic fabrics are much more difficult to ignite. They do not have the individual fibers exposed over the surface, and when ignition does occur the actual burning is relatively slow as, for example, duck, canvas, heavy sheeting, etc.

It is obvious, therefore, that there is quite a wide range in the flammability of various cellulosic materials which primarily depend upon their textile construction. However, ordinarily safe cotton, linen, or rayon fabrics may be made highly flammable if treated with paraffin, oil or pyroxylin (also called nitro cellulose or gun cotton) finishes, which are often used to make the fabric water repellent, less easy to soil and readily cleanable. The danger in using fabrics of high flammability in garments is that their flaming and burning when once ignited is so rapid that the wearer has too little time in which to take them off before serious injury has been done.

To protect the public from buying garments and materials intended for garments which ignite easily and burn rapidly and are, therefore, a personal fire hazard has been the aim of legislators and their legislation. Thus, some thirty years ago, England passed the "Fabrics Misdescription Act" following the death of some English children and serious injuries to others when their long napped cotton flannel sleeping garments became ignited while playing before open grate fires. Recently legislation was passed by the State of California which outlawed certain types of flammable fabrics and a Federal Bill HR2496, based on the original California law, has been sent to Congress.

To enforce any legislation on flammability, no matter how good or worthy the intent of the law may be, it is necessary to have some means, some device, some method, or some piece of apparatus by which the flammability, i.e., the ignitability and rate of burning can accurately be determined. At the time the California law was passed, no satisfactory test method had been devised for determining flammability. With Federal legislation looming ahead it was imperative that some action should be taken to develop a suitable testing method. As the National Retail Drygoods Association was fully aware of the seriousness of this condition, they requested the A.A.T.C.C. to investigate test methods.

The A.A.T.C.C. had a committee under J. R. Redmond which was studying the flameproofing of fabrics and would have taken up test methods but the need for a test apparatus was so pressing that Dr. Olney appointed a special subcommittee under the chairmanship of Dr. H. E. Hager to specifically study flammability of consumer fabrics. The matter of determining flammability is not as simple as it may seem; and there are many factors which affect the results. Thus the committee soon found out that a fabric which when tested under dry conditions would readily ignite and burn rapidly, under humid atmospheric conditions the same fabric was difficult to ignite and then burned slowly if in fact the flame did not go out. However, the committee set about devising the apparatus on which tests could be made and a discussion of these will be taken up later.

The whole matter of fabric flammability was tragically brought to the attention of Congress and the nation early in April. Three small boys were burned to death and seven others severely injured while playing about an unattended brush fire when the chaps of their cowboy suits suddenly took fire. These accidents, happening right in or near Washington, made some of the Federal legislators want to rush in and pass some drastic legislation to avoid the recurrence of such tragedies, but without a good test method, which the subcommittee was trying to evolve, no legislation could be made effective. Lest Congress enact some unwise legislation, the National Retail Drygoods Association arranged for an unofficial hearing in the Washington office of Congressman Leroy Johnson of California, sponsor of the Federal Bill, where members of the special committee demonstrated the tentative test apparatus which it was developing and the point was stressed again and again that any flammability legislation without a good test method could not effectively be enforced.

The difficulty of the test lies in the fact that all cellulosic fabrics will burn, that most of them have been used in garments through the ages with very little, if any, danger from fire to the wearer, and that only certain types of fabrics were dangerous to which any legislation would apply. Hence the test method was really a means of separating the sheep from the goats, namely, separating those fabrics which ignite and burn rapidly and are a danger, from those that are more difficult to ignite and when ignited burn more slowly and can, therefore, be put out before damage or

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injury is done. The apparatus which has been devised will be found illustrated and described in the appendix of this paper. See appendix No. 1. Various minor changes were suggested, but by and large it is essentially the same as at first designed. But in working out a method of test quite a number of changes were made in the handling of the samples and the general test procedure.

After the construction of the above mentioned apparatus which supposedly eliminates all the human element in test procedure, samples of a definite size were decided upon. Samples were cut 2"x6" in the direction of the warp, and masking to 1½"x6", covering all loose and frayed cut edges which might interfere with the final results. Exposing the sample to the flame at various angles from the horizontal to the perpendicular, were then investigated and an angle of 45° was found to be the more consistent in results. The perpendicular position on highly flammable fabrics flashed too rapidly to register on the timing device, and the horizontal position on the same fabric was too inconsistent, at times not burning the full length of the test sample. The flame when in contact with the sample passes one-half its length beyond the surface plane of the fabric when in place on the supporting grid. When testing high pile fabrics, the supporting grid would be moved farther away from the flame than when thin fabrics were under test, to compensate for the variation in thicknesses in fabrics.

A number of samples, none of which were flameproofed, were then selected covering a range from cotton sheetings to high pile fabrics, including low pile brushed rayon, cotton blankets, cotton wool, rayon mixed fabric, cotton flannelettes, viscose netting and acetate netting and tested on this apparatus with the following results. See appendix No. 2.

1. All rayon fluff knit—low brushed Bemberg face—burned only in a slight circle.
2. White cotton flannelette — low brushed face—burned in a slight circle, similar to No. 1.
3. Viscose rayon twill—medium low pile face—burned at times varying from 10 to 23 seconds.
4. Viscose rayon medium pile fabric —dense face length of pile approximately 3/32"—burned in 9.5 seconds.
5. Viscose rayon netting — burned rapidly with complete combustion in 5 to 6 seconds.
6. Acetate rayon netting—burned in 5 seconds with a very slight volume of flame, but melting during combustion, and drops of burning molten material dropping through the gird.
7. Cotton blanket fabric—burned in 10 seconds.
8. Cotton warp, 50% cotton, 25% wool and 25% rayon face blanket fabric—burned in 14.2 seconds.
9. Long pile viscose face rayon fabric—burned in 5 to 6 seconds.
10. Pyroxylin coated fabric — which did not ignite on the first one-second application of the flame, did so on the second application to the same point ignite and burn with a very intense large volume of flame.
11. Pyroxylin buttons, ornaments and combs were also tested.

Here it was found that all burned the same as the pyroxylin coated fabrics, but the ornaments, etc. made up as flowers and designs of thin sheets ignited much more rapidly than the smooth surfaced articles.

The burning times given above were averages covering a great number of tests as run in various laboratories. The difference in burning time in the same laboratory as well as in different laboratories varied several hundred per cent. It was therefore deemed necessary to condition the samples before testing.

Numerous samples of wool, silk, nylon, vinyon and velon were tested and found to be non-flammable when tested on the flammability tester. It was also found that a dressing gown made of napped cotton fabric burned very rapidly where the moisture in the atmosphere was low, but when this same gown was tested some time later when the humidity was relatively high, it was impossible to ignite the napped face.

In order to speed up the final results and overcome confusion in test procedure a single fabric was selected for concentrated study. This fabric, Princeton Knitting Mills, Inc., style 3308, all rayon knit fabric with a pile face approximately 3/32 inch in length was decided upon. See appendix No. 3.

As there are quite a few fire retardant finishes used at present composed of ammonium salts which break up on excessive heat application, they often cause a distintegration of the treated fabric when excessively heated for a prolonged time. Therefore, the temperature of 120°F. approximately 50°C. for two hours, followed by cooling in a desiccator containing calcium chloride plus cobalt chloride for an indicator overnight was investigated. The results obtained using this technique were still in excessive variance.

In an endeavor to speed up the drying procedure, an infra red lamp was suspended in the cabinet over the sample. This, however, caused an excessive drying of the exposed surface and also set up a draft which upset test results. Bone-drying the samples to be tested, after having been conditioned at 65% R.H. overnight and drying at 105°C., cooling in a desiccator for 3 minutes and testing seemed to be the more logical approach to the solution. This would put the fabric into the most hazardous condition, a condition which could be found in actual use as on a cold winter day when there is but a very slight amount of moisture present in the atmosphere. Records show that most casualties from flammable garments occur when the atmosphere contains but little moisture. It was found that conditioning the standard fabric No. 3308 at 65% R.H. overnight and drying 15 minutes at 150°C. brought it to a dry state suitable for testing. This method of procedure began to show promising results as shown by the following table.

TABLE NO. 1

Lab. No. 1	*Lab. No. 2*	*Lab. No. 3*	*Lab. No. 4*	*Lab. No. 5*	*Lab. No. 6*	*Lab. No. 7*
30 Tests	30 Tests	30 Tests	30 Tests	30 Tests	30 Tests	10 Tests
6 series	6 series	6 series	6 series	6 series	6 series	2 series
of 5	of 5	of 5	of 5	of 5	of 5	of 5
No. 1	*No. 2*	*No. 3*	*No. 4*	*No. 5*	*No. 6*	*No. 7*
Time of Burning	*Time of Burning*	*Time of Burning*	*Time of Burning*	*Time of Burning*	*Time of Burning*	*Time of Burning*
Max. 12.6	Max. 10.6	Max. 7.2	Max. 9.2	Max. 9.0	Max. 7.3	Max. 10.0
Min. 7.1	Min. 7.1	Min. 5.4	Min. 7.3	Min. 7.3	Min. 5.2	Min. 7.7
Avg. 9.7	Avg. 8.4	Avg. 6.3	Avg. 8.3	Avg. 8.0	Avg. 6.3	Avg. 8.8

The foregoing results indicate a definite trend toward correlation: tests from Labs. 3 and 6 show very good correlation and those from Labs. 2, 4 and 5 show good correlation. Laboratory 7, with only 10 tests compared to 30 in the others, shows close correlation under those conditions.

Not only was it then found necessary to control the R.H. of the fabric as well as the drying temperature and time, but also the condition of the pile face. During storage, the pressure exerted on the face, flattened it considerably. Allowing the fabric to lie flat, face up, relaxed this flattening to some degree, but never coming back to the original state. Brushing against as well as with the nap was then tried with a soft hand brush, but the human element again entered into this procedure. The amount of pressure exerted and the speed of the stroke both varied the results of the time required for burning.

TABLE NO. 2

Laboratory No. 1	*Laboratory No. 2*	*Laboratory No. 3*
1.2 seconds	3.8 seconds	5.5 seconds
1.2	2.0	8.0
1.0	1.6	6.3
1.4 Max. 1.4	7.8 Max. 7.8	7.1 Max. 8.0
1.2 Min.1.0	4.0 Min.1.6	6.2 M.n. 5.0
1.2 Avg. 1.2 sec.	2.0 Avg. 4.08 sec.	7.0 Avg. 6.4 sec.
1.2	7.2	5.0
1.0	2.8	6.1
1.0	3.4	
1.4	6.2	

A 1"x6" rubber roller used in photographic work, covered with a hooked card clothing was then devised. This roller when drawn over the fabric sample, against the hook, raised the pile to its original position. There were still some excessive discrepancies in the results, flashing time ranging from 1.6 seconds to 7 and 8 seconds. (Table No. 2.)

It was noted, however, that when removing the samples from the oven after drying and placing in the desiccator to cool, they were placed one over the other. Also when the operator placed the samples on the grid, the hand was often run over the sample to smooth any places not being flat. This naturally upset the pile face.

By following the same procedure of drying at 105°C. for 15 minutes, desiccating 3 minutes and then brushing with one stroke of the wire brush just previous to placing on the gird for testing, these variables in time were eliminated.

TABLE NO. 3

Laboratory No. 1	*Laboratory No. 2*
1.0 Second	1.2 Seconds
1.0	1.2
1.0	1.0
1.0	1.2
1.0 Max. 1.0	1.0 Max. 1.2
1.0 Min.1.0	1.2 Min. 1.0
1.0 Avg. 1.0 Sec.	1.0 Avg. 1.1 Sec.
1.0	1.2
1.0	1.0
1.0	1.0
1.0	
1.0	

A brown colored cotton fabric the same as the previous fabric was also tested, giving the following results. (Table No. 5.) See appendix No. 4.

A cotton chenille gave quite similar results. Flashing in 2.0 and 2.1 seconds respectively in two different laboratories and this fabric also sustained a very persistent after-glow. See appendix No. 4.

Acetate rayon fabrics both close knit or woven and pile fabrics gave no flash or burning test. However, acetate rayon netting even though the rate of burning was relatively slow and the volume of flame small, did burn, dropping a residue of still burning molten material through the grid. It has also been found that acetate rayon even though relatively non-flammable, when treated with some flame-retardant chemicals, becomes quite flammable.

It can therefore be concluded that (1) wool, silk, nylon, vinyon and velon fabrics offer no flammability hazard. (2) Cotton is just as flammable as regenerated type rayon under identical construction and testing conditions. (3) With cotton having a normal moisture content of 6½% as compared to regenerated type rayon with 11%, it is reasonable to conclude that cotton will come to the critical point much more rapidly than rayon. (4) If the samples of any one fabric are all in identical condition as to moisture content and physical condition of the face being tested, very close correlation of results within one laboratory and in any other laboratory can be arrived at as has been proven by the tables shown on this page. (5) Certain coated fabrics, although generally slow to ignite, burn with a violent flame which is difficult to extinguish and therefore offers a very definite hazard.

TABLE NO 4

Laboratory No. 1	*Laboratory No. 2*	*Laboratory No. 3*
1.0 Second	1.2 Seconds	1.0 Second
1.0	1.4	1.2
1.0	1.0	1.0
1.0	1.2	1.0
1.5 Max. 1.5	1.0 Max. 1.4	1.2 Max. 1.2
1.0 Min. 1.0	1.2 Min. 1.2	1.0 Min. 1.0
1.0 Avg. 1.12 Sec.	1.2 Avg. 1.17 Sec.	1.0 Avg. 1.04 Sec.
	1.4	1.0
	1.0	1.0
		1.0

White cotton long napped fabric (nap approximately ⅜" in length) was also tested by the foregoing procedure. This also gave very consistent results. See appendix No. 4. (Table No. 4.)

TABLE NO. 5

Laboratory No. 1	*Laboratory No. 2*	*Laboratory No. 3*
1.0 Second	1.2 Seconds	1.2 Seconds
1.0	1.0	1.0
1.0	1.0	1.2
1.0	1.4.	1.2
1.5 Max. 1.5	1.2 Max. 1.4	1.0 Max. 1.2
1.25 Min. 1.0	1.0 Min.1.0	1.0 Min. 1.0
1.0 Avg. 1.15 Sec.	1.0 Avg. 1.08 Sec.	1.0 Avg. 1.08 Sec.
1.0	1.0	1.2
1.0	1.0	1.0
1.0	1.0	1.0
1.5		
1.5		

Appendix—

OPERATING INSTRUCTIONS AND TEST PROCEDURE FOR FLAMMABILITY TESTER

Scope

The object of this test procedure and the Flammability Tester is to evaluate textile materials for flammability characteristics by measurement of rate of burning.

Procedure

I. Preparation of samples.
   - A. Five test specimens shall be cut 6" long by 2" wide in either direction unless there is a permanent fixation of the pile or nap fibers in one direction whereupon samples shall be cut in both length and width directions to determine that of the least resistance.
   - B. Samples shall be dried in an oven maintained at 105° C. ± 2.5°C. for a period of 15 minutes and then placed in a desiccator containing dry calcium chloride with cobalt chloride for a moisture indicator—to cool (approx. 3 min.) and tested immediately.

II. Method of Testing
   - A. Test specimens are entered on the 45° rack of the flammability tester and the rate of burning in seconds for five samples is recorded and averaged for the test results.

III. Test Apparatus (Description of)
   - A. Draft proof chamber with adjustable top
     1. This metal chamber prevents air circulation around the specimen rack and flame but permits free ventilation for rapid oxidation.
     2. The top is adjustable and removable.
   - B. The specimen rack is fixed at an angle of 45° and consists of a 4"x7" framework strung with heat transmitting wire laced horizontally.
   - C. Specimen shield.
     1. This shield controlled by a hand lever covers all but 1½" of the width of the test specimen for the full length.
     2. Shield is raised for the in-

sertion of test specimens and must be brought to bear on the sample face before the start of the test.

D. Indicating Finger
   1. The forepart of this finger rests on the wire lacings when the sample rack is brought all the way forward.
   2. By means of this finger, the thickness of the sample is compensated for in the throw of the gas nozzle.

E. Control Knobs
   1. There are two of these knobs which hold the rack in test position.
   2. The knobs can be reached under the stage of the cabinet and permit forward and backward movement of the rack when loosened.

F. Gas Nozzle
   1. The gas jet consists of a 36 gauge hypodermic needle protected by a copper shield formed around it.

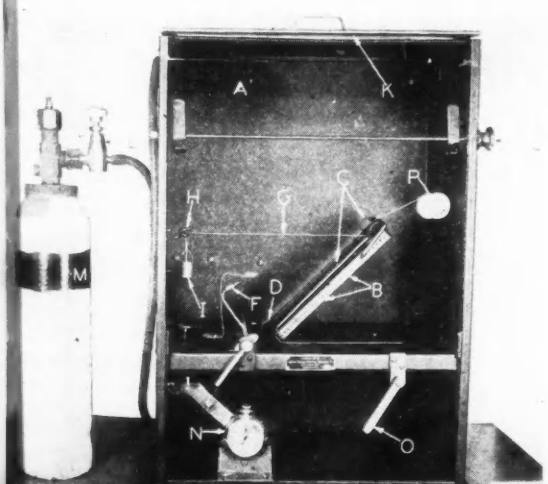
G. Stop Cord
   1. This cord stretched from the spool "P" down over the top of the rack and through a loop in the shield and across to the stop mechanism measures the vertical height of the flame.

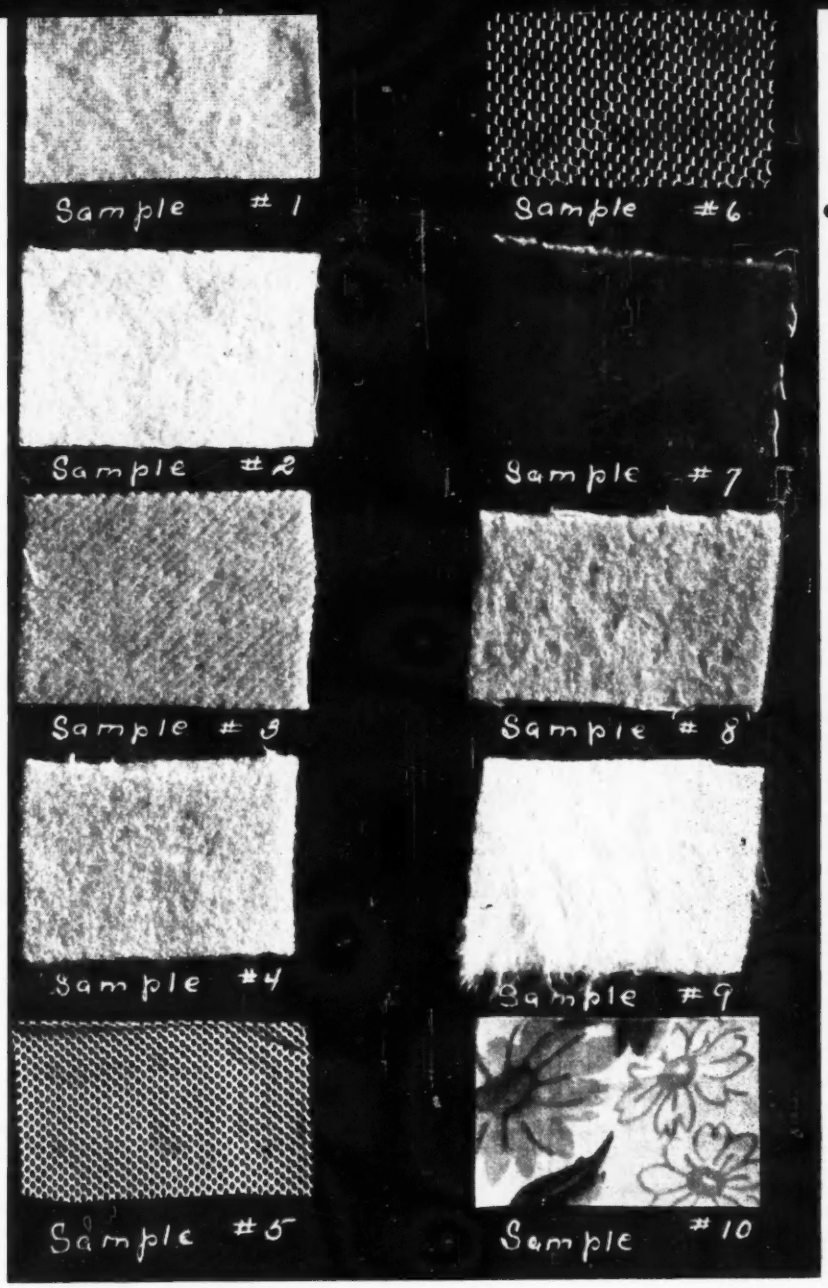
H. Pulley or Eye
   1. Support and guide for stop cord.

I. Stop Weight
   1. The weight attached by means of a clip to the stop cord in dropping actuates the stop motion.

J. Slide Door Control
   1. This knob moves the catch mechanism used to hold the sliding door (not shown in actual position) in an open condition for insertion of test specimens.

APPENDIX NO. 1





APPENDIX NO. 2

K. Slide Door
   1. A glass door (shown in end view) in its normal position slides in the grooves at the front of the cabinet.

L. Fuel Control Valve
   1. Consists of a sensitive control device for regulating the fuel supply at the tank.
   2. The valve ends in a ½" female connection for attachment to the standard Butane tank of two pounds capacity.

APPENDIX NO. 3

3. A flow meter (not shown) is used to bring the fuel supply to test level by means of the control valve.

M. cp Butane Container
1. This fuel supply which is not furnished as part of the test equipment, is a No. 4 cylinder of cp Butane.

N. Stop Watch and Timing Mechanism
1. This watch, by means of special attachments, is actuated to a start by connection with the gas jet "F."
2. A driving mchanism on rear of cabinet (not shown) moves the gas jet to its most forward position and automatically starts the timing at the moment of flame impact.
3. The falling weight, "I" when caused to move by severance of Cord "G" stops the watch.
4. Timing is read directly

O. Starting Lever
1. This lever is operated from left to right in one stroke and is released to operate the gas jet.

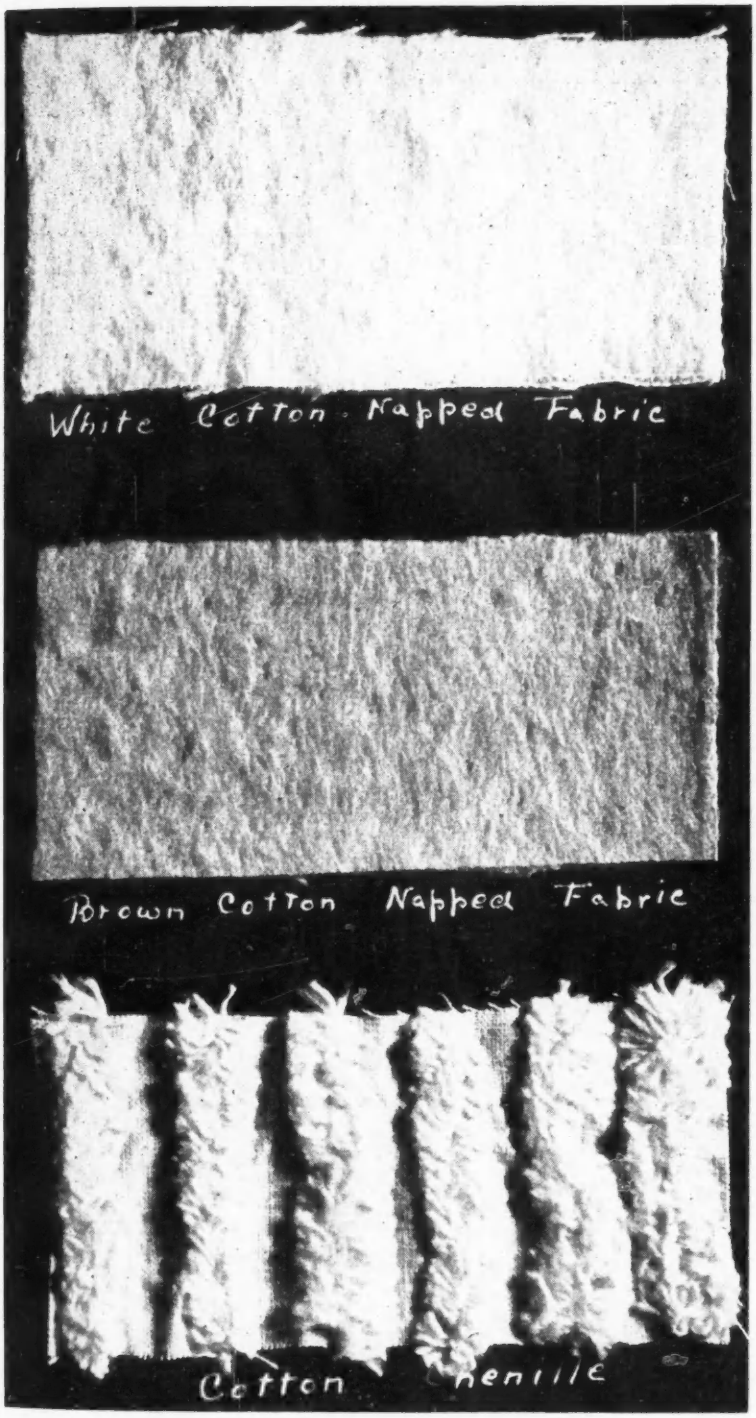
P. Cord Supply
1. This supply, consisting of a spool of No. 50's mercerized cotton sewing thread, is fastened to the side of the chamber and can be withdrawn by releasing the thumb screw holding same in position.

IV Directions for Use
A. The control valve from the fuel supply is opened and adjusted to the test level. Some time has to be allowed in order to drive the air from the fuel lines. This interval should be approximately five minutes. A flame is then applied to the gas nozzle in its starting position. The sample rack with the test specimen in place is brought forward to the point where the indicating finger touches the face of the sample and is then locked. The shield over the test specimen should be in place when the adjustment is made.
B. The cord is strung through the loop in the shield and across the top of the sample over the guide ring and then the weight is hooked in place close to and just below the guide.
C. The stop watch should be set at zero at the start of each test.
D. The slide door should be in closed position at the start of the test.
E. Bringing the starting lever over to the extreme right and releasing it will start the timing mechanism that supplies the gas jet to the face of the fabric.
F. Timing is automatically recorded by the watch starting upon application of the flame and ending with the cord burning through at the end when the flames reach the cord line which is horizontal to the top of the sample.
G. Tests should be conducted in a draft-free room.

PROPOSED TENTATIVE METHOD FOR TESTING FLAMMABILITY OF CONSUMER TEXTILES

With the acceptance of the above described apparatus for the determination of flammability of fabrics, the following procedure was proposed as a method for testing of consumer fabrics.

A small piece of the material in question is exposed to an open flame. If the material burns, ten or more samples are cut 2"x6" in the direction of the warp or lengthwise of the material. The face surface of the samples are then restored to their original condition, brushing with the wire brush if necessary, oven dried of 105°C. for at least 15 minutes, cooled in a desiccator over calcium chloride for



APPENDIX NO. 4

3 minutes, the face again brushed before placing on the grid and tested with the flammability tester.

If the sample does not burn or burns with retardation, emerse sufficient of the material for test samples in a bath of water at 80° to 85°F. with slight working for a period of 3 minutes. The volume of the bath should be 30 times as much water as material. Extract to remove excess of water and repeat twice more. Dry and allow it to regain its normal moisture content. The material is then cut into samples 2"x6", the face restored to its original condition, oven dried at 105°C. for at least 15 minutes, cooled in a desiccator for 3 minutes, the nap again brushed previous to placing on the grid and tested on the flammability tester.

The above method of pre-handling of material before testing should remove most of the water soluble fire retardant finishes. As these tests are for consumer materials, further pre-working is proposed.

If the sample does not burn on the initial application of the flame, sufficient material for test samples is washed in a soap solution corresponding to domestic washing.

WASHING PROCEDURE: Make up a bath containing 0.5% neutral chip soap, volume of bath 30 times the weight of material. Warm the bath to 95° to 100°F., immerse the material and work gently by hand for 5 minutes. Rinse twice in clear water at 80° to 85°F., extract and dry. The same procedure for flammability is then to be followed as has already been described above.

PHOTOS of the EXHIBITS at the VICTORY CONVENTION will appear in FUTURE ISSUES

Intersectional Contest—

PRACTICAL EFFECT OF STRETCHING SYNTHETIC YARNS*

Presented by the

PIEDMONT SECTION

COMMITTEE

Piedmont Section

JOHN E. BELL, *Chairman*

Paper Presented By

R. H. SOUTHER

THE successful handling and processing of textile yarns and their fabrication into woven and finished cloths is predicated upon holding to a minimum, mechanical damage to the yarn and the retention of as much as possible, of their original strength and other physical properties. This aim is dependent to a large degree upon the ultimate strength of the yarn but also upon the ratio between this strength and the ability to stretch without breaking. The synthetic yarns follow a more or less characteristic pattern in this respect.

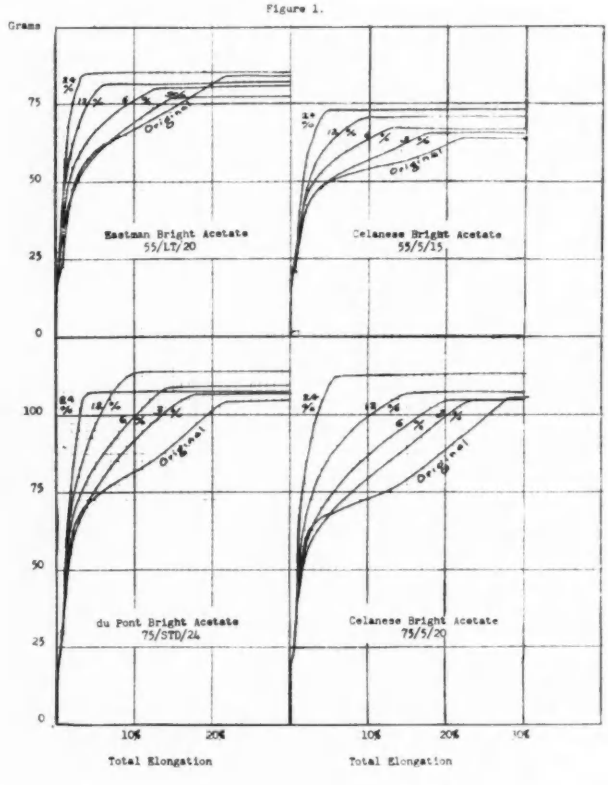
When any yarns, but particularly those which use cellulose as their raw material, are stretched dry and even in an atmosphere of high relative humidity, the effect of this strain is relatively obvious and immediate, since where an excessive stress is applied mechanical breakage will occur and an enhanced luster is produced in those fibers which do not actually reach their breaking point. When yarns are stretched while wet and heated, and this is particularly true of the synthetic yarns, a certain degree of molecular reorientation occurs within the fibers, which is not obvious from a casual inspection and which does not result in an immediate breaking of the filaments. This study is intended to show the effect of such stretching, with particular reference to the stretching incurred during slashing or sizing of synthetic warp yarns.

Samples of representative yarns were immersed in water at 65°C., stretched to a predetermined extent, dried and conditioned at 65% relative humidity, 70°F., while still held under tension to retain the stretched length. Specimens prepared in this way were then broken on an inclined plane tester with results shown in the accompanying stress-strain curves. The method of stretching is the same that would be met in commercial slashing, in which the yarn passes through a size bath held at an elevated temperature while under tension and this tension is maintained during drying and storage on a loom beam.

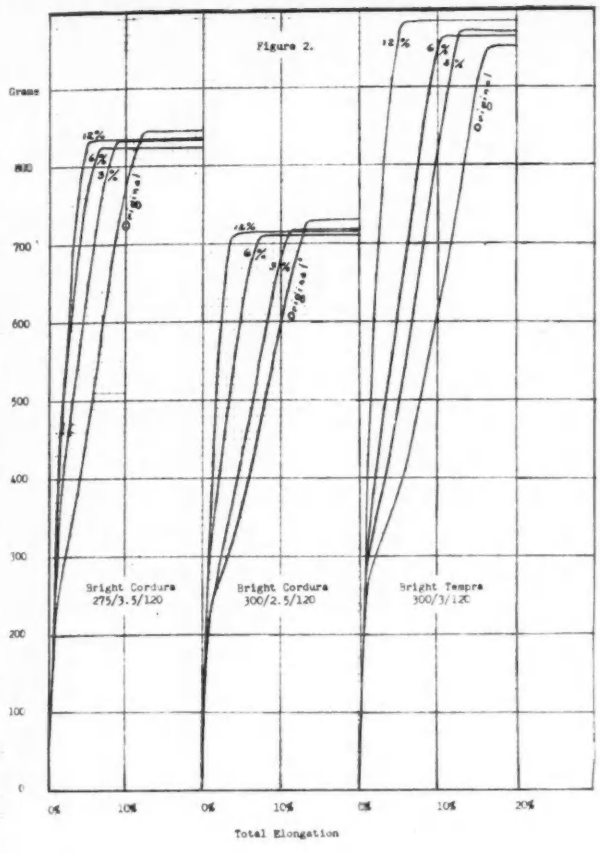
Figure 1 shows the results of two different sizes and three different makes of cellulose acetate yarns. The 55 denier, 20 filament, Eastman yarn shows an original total elongation of 21.7% and a total elongation of 14.9% after stretching 3%. This is further decreased to 13% in the sample that was stretched as in slashing 6%. A 12% stretch in slashing reduced the total elongation to 6.1%, while after the yarn had been stretched 24%, the total elongation was found to be 3.2%. Celanese 55 denier yarn follows a somewhat similar pattern with an original total of 21.9%, a loss of 4.2% after stretching 3%, a loss of 8.9% after stretching 6.0%, a loss of 11.9% after stretching 12.0% and a loss of 15.9% after stretching 24%. Examination of the two charts in Figure 1 covering similar tests made on 75 denier du Pont cellulose acetate yarn and 75 denier Celanese yarn shows that, in general, the loss in total elongation is relatively proportional to the actual slashing stretch until a maximum of 10-12% is obtained. If the yarn is stretched beyond this point, the loss in total elongation is less than the total stretch. It is to be noted also that the tensile strength of the yarn does not suffer; in fact, in most cases it increases slightly. If this increase were calculated upon the basis of yarn diameter, it would be even more pronounced. However, in the practical handling of yarns, we are more concerned with total tensile strength than we are with the question of strength per denier or per area cross section.

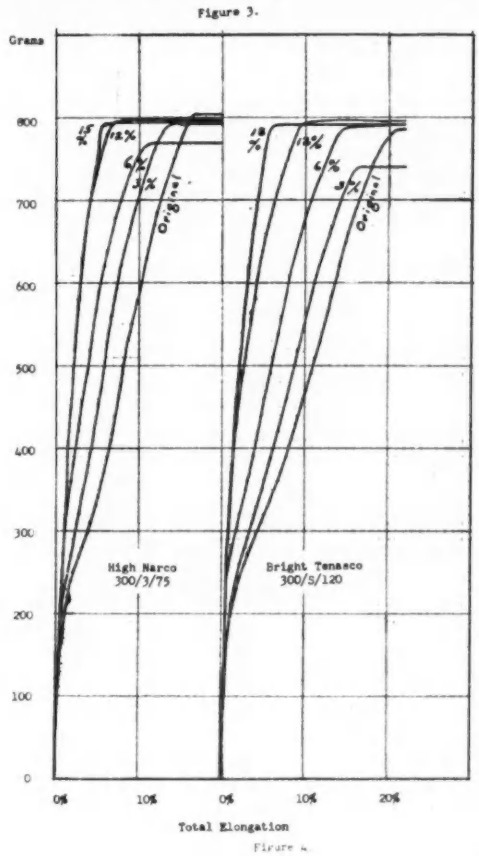
Similar tests made on five different 275 denier and 300 denier medium and high

Figure 1.



* Presented at Intersectional Contest, Victory Convention, Hotel Pennsylvania, New York City, January 5, 1946.





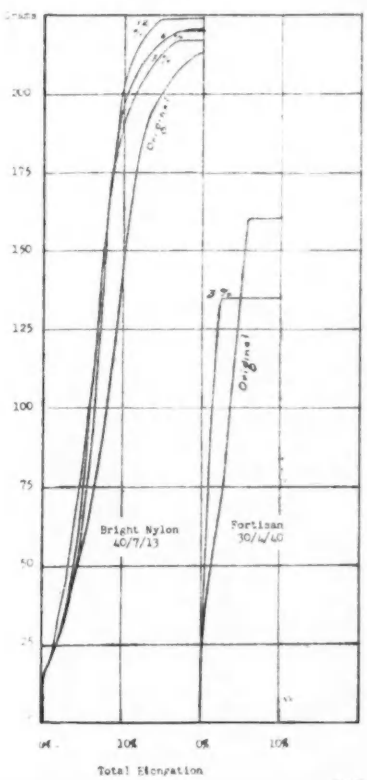
tenacity viscose rayons show a similar effect. Here, however, the correlation between stretch in slashing and loss in total elongation does not go beyond the 6% limit and tests made on yarn stretched 12% or more show the loss in total elongation to be much less than the yarn has actually been stretched. These results are shown in Figures 2 and 3.

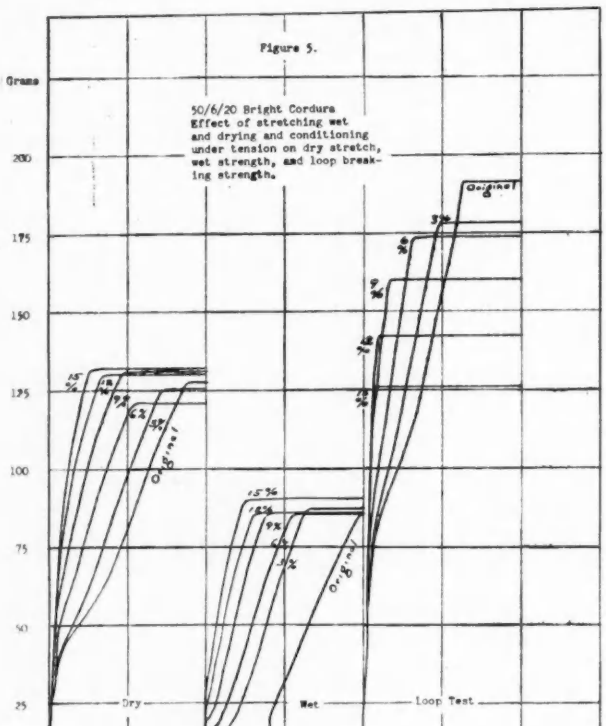
Figure 4 shows the same method applied to 40 denier Nylon and 30 denier Fortisan. Nylon shows a decrease in total elongation of 2.8%, when stretched 3% in slashing, and in the test shown in this figure a further increase of only 0.2% when stretched. It shows a loss in total elongation of only 5% after stretching 12% in slashing. Fortisan, with an original total elongation of only 5.7% fares rather badly when stretched, dropping to 2.4% when stretched 3% and showing a considerable loss in strength as well. The nylon shows a slight increase in strength.

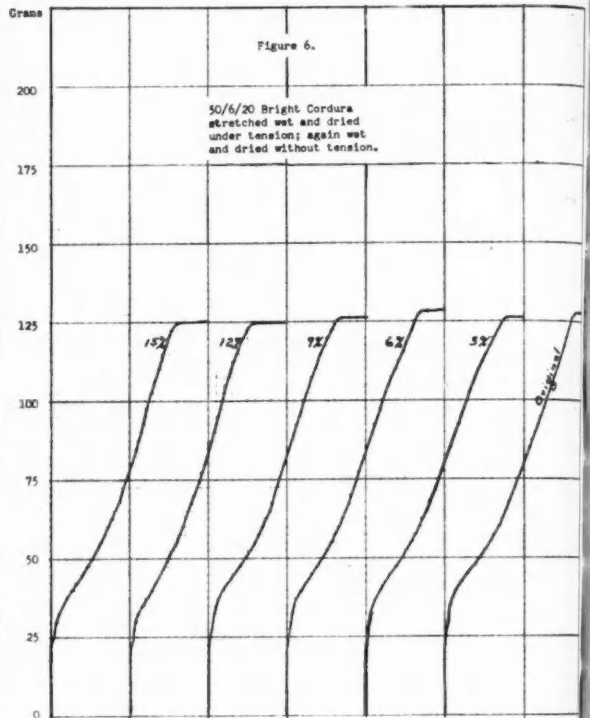
In Figure 5, 50 denier, Bright Cordura yarn shows a fairly consistent loss in total elongation until just past the 6% mark, after which the difference decreases. When tested wet, this yarn does not show any closer correlation with stretching than dry. Tests for loop breaking strength on this yarn give an interesting side light on the effect of stretching, which does not appear in either the total tensile strength or the total elongation. This is also shown in Figure 5, where it will be noted how progressively the loop strength decreases as the stretch in slashing is raised.

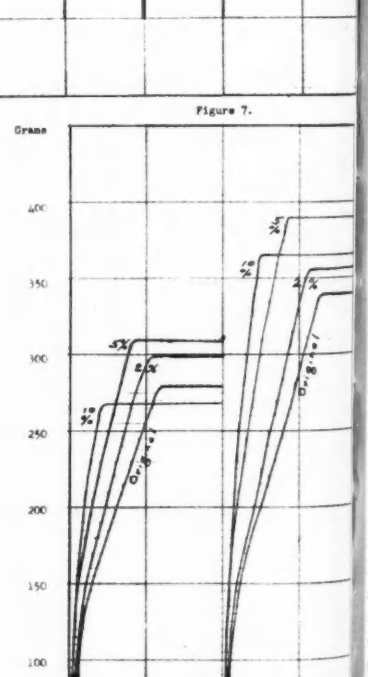
Figure 6, which shows tests also made on the 50 denier Cordura yarn, shows that, when this yarn is stretched as outlined previously, it is able to return essentially to its original length and to regain its original strength and elongation by rewetting and drying without tension. even when stretched in slashing as high as 15%. This indicates no essential damage to the yarn when it is stretched in this way and contrasts violently with the effect of stretching such a yarn 12% or 15% while dry.

Figure 7 shows the results of similar tests made on rayon staple yarns. Two yarns were selected, one in 20/1 and the other 20/2, both made up of 55% 3 denier, 2½" dull viscose, 15% 1½ denier, 1-9/16" bright viscose, 25% 3 denier, 2½" dull acetate, and 5% 3 denier, 1½" bright acetate. As was to be









expected, the mechanical effect of stretching while wet materially increased the strength of the yarn at the same time the total elongation is being reduced. In this it would be comparable with wet spinning. Somewhere between 5% and 10% of slashing stretch, the strength begins to drop. In the case of the 2 ply yarn the strength, after stretching 10%, is still appreciably higher than the original strength of the yarn. In the single's yarn the strength, after stretching 10%, is less than it originally was. This can probably be explained as a difference in reaction of a plied yarn which contains additional twist as compared with the single's and which enables it to withstand stretching with less loss because the individual fibers themselves are not strained to the same extent.

The practical conclusions, which can be drawn from this series of experiments, must be tied in rather closely with known or assumed requirements for a given yarn to enable it to be handled, twisted, woven and finally dyed and finished successfully. In addition, any special requirements, which a woven fabric must meet, must also be considered. In general, if a yarn is permitted to retain at least 15% of total elongation, it can withstand all of the mechanical effects incident to processing. Therefore, before any specifications are adopted covering the amount of stretch that can be given any yarn, the original elongation must be known and its reaction under conditions incident to stretching must be determined. Each class of fibers will require a variation in the general method. For example, the acetate yarns can be stretched to a greater extent than the viscose type rayons. Similarly, the low tenacity viscose type rayons can be stretched more than the medium and high tenacity rayon yarns. Much work is still to be done in tying in actual weaving and processing quality records with the physical characteristics of yarns, but enough data has been collected to show that the broad conclusions noted above are generally sound.

Intersectional Contest—

HOW DIFFERENT TYPES OF DYESTUFFS AFFECT THE RATE OF DETERIORATION OF CLOTH EXPOSED TO WEATHERING*

Presented by the
SOUTHEASTERN SECTION

COMMITTEE

Southeastern Section

MATTHEW T. BARNHILL
Chairman
R. O. SIMMONS
J. C. FARROW
J. E. SMENNER

Paper Presented By
A. KEMPTON HAYNES

PURPOSE

The primary purpose of this research is to determine whether different types of cotton dyestuffs have any effect on the rates of deterioration of cloth when such cloth is dyed with these dyes and subsequently exposed to weathering.

It is also hoped that in scope this work will prove sufficiently broad to be of interest to many who may be working on other phases of the subject of weathering.

PROCEDURE

Dyed and undyed cloth was exposed to weathering simultaneously in Biddeford, Maine, Lindale, Georgia, and Birmingham, Alabama. The manner in which these samples were dyed and otherwise prepared will be explained presently.

Warp breaks, and in some cases viscosity readings, were used to measure the deterioration of the fabric after weathering.

Spectrophotometric calculations have been used to show the actual degree of color fading on the samples exposed to weathering in Birmingham. In comparing these samples to the ones exposed in Biddeford and Lindale the amount of fading was estimated by matching the faded samples together under a Macbeth Color Identification Lamp.

As an interesting comparison, accelerated fading, accelerated weathering, and accelerated aging tests were made on all types of fabric being otherwise tested.

PROCEDURE USED IN DYEING SAMPLES

A single cut of 3.60 sheeting (which had been singed, desized, kier boiled and chlorine bleached) was equally divided into six pieces. One piece was retained as an undyed control sample. The remaining five were dyed with blue dyestuffs to give as nearly as possible the same depth of shade. All dyeings were made on a conventional type cotton dye jig and methods were consistent with those recommended by the manufacturers of the dyestuffs.

The following is an outline of the five dyeings:

Type Dyestuff	*Approximate Formula and Method*
Naphthol	Prepared with 1-1/3% Naphthol AS - SW, salt rinsed, coupled with Naphthanil Diazo Blue B Salt, washed, soaped at 200 F., washed and shelled up cold.
Vat	Dyed with 5% Indanthrene Navy Blue BRP Paste using the pigment method. It was dyed at 140 F., washed, oxidized with sodium perborate, soaped at 200 F., washed and shelled up cold.
Diazotized and Developed	Dyed with 1% Diaminogen Blue NAA at the boil with the addition of salt. It was then diazotized, washed, and coupled with Beta Naphthol, after which it was again washed, soaped at 160 F., washed at 160 F. and shelled up.
Sulfur	Dyed with 4% Calcogene Blue 6RCF conc. at 200 F. with the addition of salt. It was then washed, oxidized with bichromate and acetic acid, washed, soaped at 200 F., washed and shelled up.
Light-Fast Direct	Dyed with 1% Pontamine Fast Blue SFL conc. at the boil with the addition of salt. It was then given two ends in a dilute salt rinse and shelled up.

After these pieces of cloth were dyed, they were sewed together, put on a jig, and were washed cold through a large number of ends until they were as nearly neutral as possible. The bleached but undyed control sample was finished separately from the dyed pieces but in a similar manner.

ACTUAL pH OF SHEETING SAMPLES

The following table shows the actual pH of the finished samples before exposure to weather.

Fabric	*Average pH*
Undyed Bleach	6.79
Naphthol Dyed	6.70
Vat Dyed	6.99
D. and D. Dyed	6.57
Sulfur Dyed	6.56
Light-Fast Direct Dyed	6.94

Each of the above readings represent the average pH of samples from four different places in the fabric specified. The actual pH tests were conducted according to U. S. Army specification outlined in 6-322.

MOUNTING SAMPLES FOR EXPOSURE TO WEATHERING

A ten foot sample of each type of dyed fabric as well as the undyed bleach control, was mounted on frames of similar construction at Birmingham, Lindale, and Biddeford. Each frame was set up outside on the roof of a building to allow the full effect of weathering.

The construction of the frames was either pine flooring or ply wood. Each consisted of a solid smooth surface upon which the cloth was mounted and fastened securely at the selvages. The mounting was at 45 degrees and the cloth was given an Eastern exposure to protect it from unnecessary wind damage which might occur from Southerly or Westerly winds at this season of the year.

TAKING SAMPLES AFTER EXPOSURE FOR WARP BREAK TESTS

At intervals of two weeks after weather exposure was started a seven inch strip of cloth cut from selvage to selvage was removed from each sample being tested. From each of these strips eight 4"x6" specimens were cut and broken warpwise using standard A.S.T.M. procedure on a Scott Vertical Tester of 150 lbs. to 200 lbs. capacity in the lower limits.

Before breaks were made all samples were dried at not over 100 F. until the dry side of 7% regain was reached. They were then conditioned 24 hours at 65% R.H. and 70 F. after-which the breaks were made.

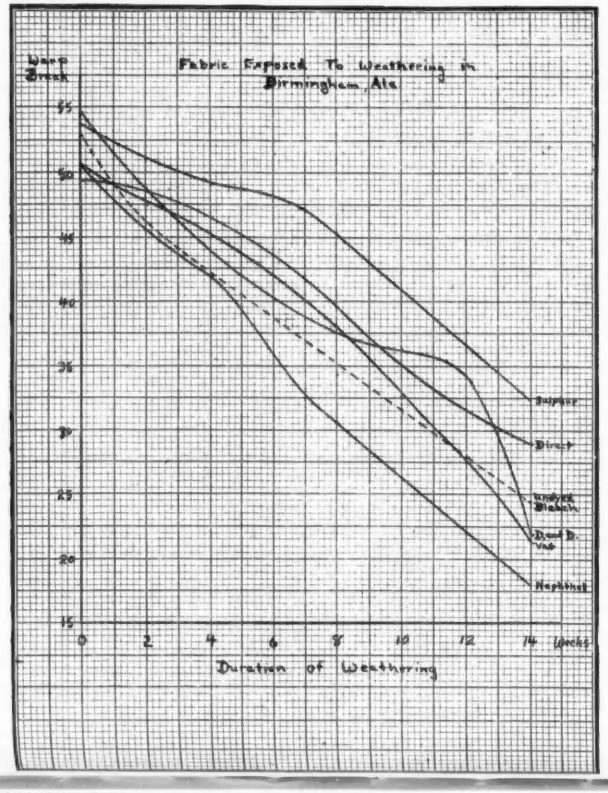
* Presented at Intersectional Contest, Victory Convention, Hotel Pennsylvania, New York City, January 6, 1946.

TABLE SHOWING WARP BREAKS OF FABRIC EXPOSED AT BIRMINGHAM, ALA.

Fabric	Unexposed Original	Apr. 14	Apr. 28	May 12	May 26	June 9	June 23	July 7
Undyed Bleach	52.8	46.1	42.0	38.5	34.4	31.3	29.0	22.9
Naphthol Dyed	50.4	45.5	41.9	35.9	30.6	26.0	22.0	17.7
Vat Dyed	50.5	47.4	45.3	40.8	38.0	32.6	27.7	21.5
D. and D Dyed	54.6	48.6	44.9	40.0	37.5	36.4	34.9	22.1
Sulfur Dyed	53.6	52.0	48.9	51.5	45.3	40.4	37.6	31.6
Light-Fast Direct Dyed	49.4	48.4	46.4	43.1	40.5	33.8	32.7	29.1

Each break shown in this table is an average of eight breaks.
April 14 reading represents after two weeks exposure.

Each break shown in this table is an average of eight breaks. April 14 reading represents after two weeks exposure.



WEATHER CONDITIONS IN BIRMINGHAM, ALA.

Date	TEMPERATURE Maximum	Minimum	Rainfall	WIND Prevailing Direction	Highest Velocity	Average Cloudiness
4/1/45	76	60	1.02	SE	42	10
4/2	75	55	.01	S & SW	22	8
4/3	85	52	.00	SE	13	3
4/4	81	49	T	S	26	9+
4/5	55	39	.00	N	26	3
4/6	60	39	.00	E	16	4
4/7	70	40	.00	E & NE	15	0
4/8	74	42	.00	S	16	3
4/9	77	47	.00	E	17	7
4/10	81	49	.00	SE	21	5
4/11	83	56	.00	SE	16	4
4/12	82	54	.00	SE	16	1
4/13	85	59	.00	SE	13	5
4/14	85	59	.00	S	16	4
4/15	86	60	.00	S	17	5
4/16	81	59	2.07	S	29	9+
4/17	75	50	.05	N	16	6
4/18	72	45	.00	N	17	1—
4/19	72	45	.00	E	17	1
4/20	82	48	.00	NE	13	5
4/21	83	53	.00	NE	10	8
4/22	68	61	.90	E	25	9+
4/23	78	61	.05	SE	13	8
4/24	81	64	.61	S	17	7
4/25	83	61	.22	S	15	5
4/26	75	50	.00	N & SW	19	2
4/27	74	44	.02	NE	17	2
4/28	63	50	1.21	SE	40	10
4/29	64	45	.04	N	17	9+
4/30	70	39	.00	N	17	0
5/1/45	74	44	.01	S	13	5
5/2	76	55	T	SW	23	6
5/3	62	50	.08	NW	26	6
5/4	65	46	T	NW	27	6
5/5	70	41	.00	N	18	2
5/6	76	41	.00	SW	17	1
5/7	75	52	.75	S	34	9
5/8	74	48	T	NW	15	4
5/9	78	45	.00	E	16	6
5/10	80	55	.00	SW	24	9
5/11	64	51	1.03	E	16	9+
5/12	79	58	1.08	E	31	9
5/13	82	62	T	SW	9	9
5/14	86	61	.00	S	17	5
5/15	85	67	.00	S	24	6
5/16	79	61	.09	S	27	9+
5/17	66	51	.06	NW	22	9+
5/18	59	50	.00	NW	15	10
5/19	77	53	.00	N	16	2
5/20	83	50	.00	SE	13	1—
5/21	83	60	.00	S	22	5
5/22	80	55	.14	NW	17	9
5/23	81	48	.00	E	20	1—
5/24	85	50	.00	NE	17	3
5/25	87	60	.00	S & SW	17	7
5/26	88	65	T	SW	23	6
5/27	89	61	.00	NE	10	8
5/28	91	64	.00	NE & SW	17	7
5/29	89	62	.00	NW	17	6
5/30	91	67	.00	NW	13	3
5/31	94	64	.00	NE	12	1—
6/1/45	93	68	.00	SW	20	2
6/2	87	64	.01	SW	26	7
6/3	88	61	.00	NW	17	5
6/4	81	57	T	N	14	3
6/5	84	51	.00	NE	13	2
6/6	79	60	.24	E & SE	23	8
6/7	89	65	.00	SW	19	9+
6/8	91	70	.00	SW	18	6
6/9	92	69	.00	SW	21	6
6/10	92	67	.24	SW	31	8
6/11	90	71	.02	SW	18	8
6/12	93	68	.00	S	17	4
6/13	92	70	T	SE	21	8

WEATHER CONDITIONS IN BIRMINGHAM, ALA. (Cont.)

WEATHER CONDITIONS IN BIRMINGHAM, ALA. (Cont.)

Date	Temperature Minimum	Temperature Minimum	Rainfall	Prevailing Direction	Wind Highest Velocity	Average Cloudiness
6/14	90	70	.05	SE	29	7
6/15	85	69	.05	SE	14	8
6/16	86	67	T	SE	23	8
6/17	86	67	.29	SE	31	8
6/18	78	64	.05	SW	26	9+
6/19	83	65	T	NW	18	8
6/20	87	61	.00	E & NW	13	5
6/21	90	61	.00	NW	13	5
6/22	91	62	.00	NE	16	4
6/23	94	70	.00	NE	16	3
6/24	94	67	.00	E	15	4
6/25	95	69	.00	NW	17	3
6/26	94	67	.00	NW	13	3
6/27	94	70	.00	NE & SE	9	3
6/28	97	71	.00	SW	17	3
6/29	98	73	.00	SW	14	4
6/30	95	67	.11	SE	47	5
7/1/45	95	72	.00	NE	17	5
7/2	88	71	.00	N	17	6
7/3	87	63	.00	NE	15	5
7/4	87	67	.00	E & SE	12	6
7/5	95	71	.00	SE	20	7
7/6	92	71	T	NW	8	8
7/7	94	67	.11	E	17	7

Scale of Cloudiness taken sunrise to sunset: 0 to 3, CLEAR; 4 to 7, PARTLY CLOUDY; 8 to 10, CLOUDY; T indicates TRACE.

Month	Prevailing Direction of Wind Direction	Barometric Pressure Monthly Mean	Highest	Lowest
April, 1945	SE	30.07	30.55	29.55
May	NW	29.98	30.17	29.70
June	SW	29.99	30.22	29.81
July	NE	30.00	30.28	29.79

The data in these charts were compiled in the Birmingham Airport Station.
All information was furnished by Edgar C. Horton of the Birmingham Weather Bureau.

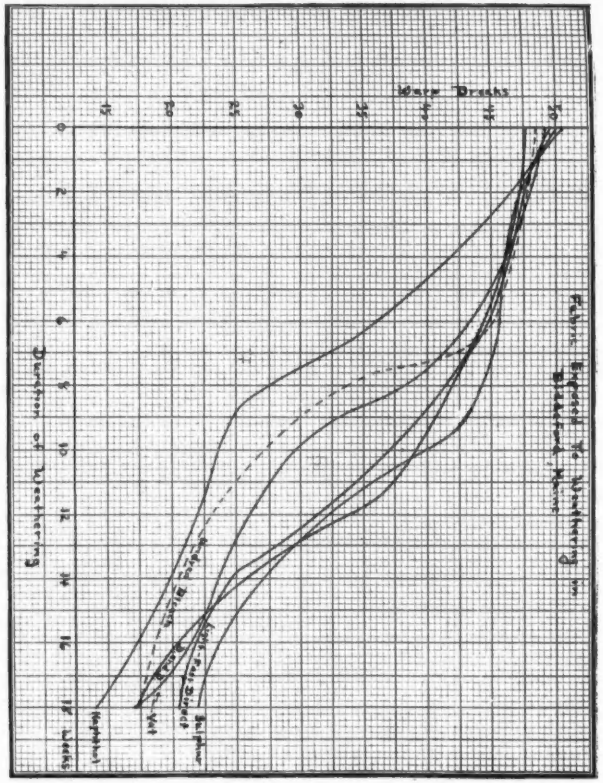


TABLE SHOWING WARP BREAKS OF FABRIC EXPOSED AT BIDDEFORD, MAINE

Fabric	Unexposed Original	Apr. 23	May 6	May 20	June 4	June 18	July 1	July 16	July 30	Aug. 13
Undyed Bleach	48.4	...	46.7	45.5	33.7	26.6	23.5	20.6	19.6	17.2
Naphthol Dyed	50.0	45.5	43.0	34.2	24.8	24.0	23.1	19.5	18.4	14.2
Vat Dyed	49.1	...	46.2	43.8	37.7	29.3	25.5	22.6	22.3	17.0
D. and D. Dyed	49.5	47.2	46.9	43.7	42.1	41.9	35.1	23.2	22.7	17.7
Sulfur Dyed	50.6	47.1	46.1	45.8	44.4	41.6	33.6	25.5	23.0	23.8
Light-Fast Direct Dyed	47.6	...	46.2	45.7	41.2	38.1	31.3	25.0	21.9	21.2

The break obtained on April 23 for the BLEACH, VAT, and DIRECT samples was much lower than the corresponding breaks for May 6. This is illogical, so these readings were left out of the table.

Each break shown in this table is an average of nine breaks. April 23 reading represents after two weeks exposure.

WEATHER CONDITIONS IN BIDDEFORD, MAINE

Date	Temperature 8.00 A.M.	Temperature 12.00 M.	Temperature 5.00 P.M.	Weather 8.00 A.M.	Weather 12.00 M.	Weather 5.00 P.M.	Rainfall	
4/9/45	39	66	60	C	C	C	0.00	Heavy night fog
4/10	41	65	60	X—	C	X—	0.00	Light night fog
4/11	39	74	70	C	H	C	0.00	
4/12	56	78	80	C	C	C	0.00	
4/13	66	78	78	C	C	C	0.00	
4/14	69	75	70	H—	H—	H	0.00	East wind
4/15	42	45	50	C	C	C	0.00	North wind
4/16	31	65	60	C	H	O	0.00	Heavy frost
4/17	50	67	70	D	X	R—	0.04	
4/18	50	68	70	C	C	C	0.00	
4/19	49	67	62	C	C	C	0.00	
4/20	45	58	60	O	C	O	0.00	
4/21	48	56	63	C	O	O	0.30	Rain at night
4/22	47	48	48	O	O	C	0.00	
4/23	32	54	52	C	C	C	0.00	
4/24	37	56	55	C	C	C	0.00	
4/25	47	54	48	O	O	R	0.17	
4/26	42	48	47	R	D	O	0.45	

WEATHER CONDITIONS IN BIDDEFORD, MAINE (Cont.)

Date	Temperature 8.00 A.M.	Temperature 12.00 M.	Temperature 5.00 P.M.	Weather 8.00 A.M.	Weather 12.00 M.	Weather 5.00 P.M.	Rainfall	
4/27	45	46	48	R	R	D	0.37	
4/28	44	53	55	D	R	D	0.00	
4/29	45	51	53	O	C	C	0.00	
4/30	49	54	52	X	D	C	0.00	
5/1	46	50	51	O	O	X	0.00	
5/2	43	51	51	C	X	O	0.05	
5/3/45	48	52	50	X	X	R	0.00	
5/4	42	44	44	R+	R	R+	1.18	
5/5	47	58	57	D	R	O	0.06	
5/6	45	54	53	X	O	C	0.00	Sea fog in P.M.
5/7	46	62	62	C	S	C	0.01	
5/8	50	62	58	C	C	S	0.08	
5/9	48	62	59	C	C	R	0.00	
5/10	46	48	40	X	C	R	1.24	Rain, lt. snow
5/11	37	39	48	Snow, R	R	C	1.50	3" snow overnight
5/12	44	60	60	C	O	R	0.00	
5/13	44	52	49	O	R	C	0.61	
5/14	56	71	71	C	C	C	0.00	
5/15	59	70	67	X	C	O	0.23	
5/16	51	60	59	O	C	O	0.11	
5/17	50	51	51	O	O	D	0.06	
5/18	49	58	59	R	D	O	1.18	
5/19	47	51	52	R	C	O	0.19	
5/20	58	62	63	C	O	C	0.00	
5/21	50	54	50	O	O	C	0.00	
5/22	47	49	57	O	O	C	0.00	
5/23	62	65	62	C	C	C	0.00	Fog in early A.M.
5/24	53	62	60	C	C	X	0.00	
5/25	56	63	60	C	C	C	0.00	
5/26	54	62	62	C	O	O	0.00	
5/27	49	59	57	O	O	C	0.00	
5/28/45	54	61	55	R	O	R	0.12	
5/29	60	76	68	O	C	C	0.23	
5/30	56	58	58	R	C	C	0.44	
5/31	52	58	55	C	C	C	0.00	
6/1	49	59	59	C	C	C	0.00	
6/2	54	64	62	C	C	C	0.00	
6/3	42	58	55	X	O	R	0.00	
6/4	51	58	56	O	C	O	0.00	
6/5	48	52	52	R	O	R	0.31	
6/6	52	60	62	O	X	S	0.07	
6/7	57	69	69	X	O	S	Trace	
6/8	62	64	62	C	C	C	0.04	
6/9	56	74	70	C	C	C	0.00	
6/10	68	68	60	C	O	R	Trace	
6/11	57	74	72	R	C	O	0.93	
6/12	69	82	82	C	C	X	0.04	
6/13	65	77	73	C	C	O	0.00	
6/14	64	84	84	C	C	C	0.00	
6/15	78	94	74	C	C	R	1.01	Heavy P.M. Thunderstorms
6/16	74	79	75	C	C	O	0.00	
6/17	58	62	62	O	O	O	0.22	
6/18	58	64	63	Fog	O	O	0.00	
6/19	70	76	75	C	R	O	0.00	
6/20	62	64	66	C	R	C	1.06	
6/21	60	73	66	C	C	S	0.00	
6/22/45	64	77	74	C	C	C	0.00	
6/23	68	84	78	C	C	C	0.00	
6/24	64	78	76	C	C	C	0.00	
6/25	68	80	79	C	R	O	1.53	Heavy rain at night
6/26	67	66	66	R	O	R	0.96	
6/27	61	73	70	O	O	O	0.01	
6/28	65	78	65	O	O	C	0.00	
6/29	64	76	82	O	C	C	0.00	
6/30	67	92	92	C	C	C	0.00	
7/1	70	90	90	C	C	C	0.00	
7/2	80	90	85	C	C	C	0.03	
7/3	68	80	77	C	C	C	0.03	
7/4	60	74	70	C	C	C	0.00	
7/5	68	85	80	C	C	C	0.00	
7/6	68	85	73	C	C	R	0.15	Thunderstorms
7/7	66	84	81	C	C	C	0.00	
7/8	62	81	80	C	C	C	0.08	
7/9	64	82	80	C	C	C	0.00	
7/10	66	76	71	O	R	R	0.81	Thunderstorms
7/11	60	70	68	C	C	C	0.09	
7/12	54	70	69	C	C	C	0.00	
7/13	62	77	71	C	C	C	0.00	
7/14	64	78	74	Fog	C	O	0.00	
7/15	64	72	66	O	O	R	0.96	
7/16/45	66	76	72	O	O	O	0.00	
7/17	67	77	76	O	C	O	0.00	
7/18	69	83	77	O	C	O	0.00	
7/19	72	83	84	C	C	O	0.00	
7/20	74	89	85	C	C	C	0.76	Showers in P.M.
7/21	75	80	79	C	C	C	0.00	
7/22	62	70	70	C	C	O	0.00	
7/23	65	74	70	O	O	C	0.00	
7/24	65	75	72	Fog	O	C	0.00	
7/25	65	77	75	O	O	C	0.00	
7/26	69	82	80	C	O	C	0.00	
7/27	66	78	70	C	C	C	0.00	
7/28	61	75	70	C	C	X	0.00	
7/29	64	70	70	R	R	X	0.64	
7/30	66	82	77	C	C	C	0.00	
7/31	68	80	76	C	C	C	0.00	
8/1	64	78	72	Fog	C	C	0.00	
8/2	65	75	72	Fog	C	C	0.00	
8/3	68	87	85	C	C	C	0.00	
8/4	64	78	76	C	C	X	0.00	
8/5	65	76	72	C	C	C	0.00	
8/6	60	72	71	C	O	O	0.03	
8/7	60	62	63	R	S	R	0.68	
8/8	66	81	76	O	C	C	0.00	
8/9/45	62	82	79	C	C	C	0.00	
8/10	60	82	80	C	C	C	0.00	
8/11	67	87	83	C	C	C	0.00	
8/12	62	80	84	C	C	C	0.00	

Legend: X—Cloudy
C—Clear
H—Hazy
O—Overcast
D—Drizzle
R—Rain
S—Showers

(—) means slight.
(+) means very

This information was furnished by H. D. Evans of Pepperell Mfg. Co., Biddeford, Maine.

TABLE SHOWING WARP BREAKS OF FABRIC EXPOSED AT LINDALE, GEORGIA

Fabric	Unexposed Original	Apr. 24	May 8	May 22	June 6	June 20	July 4	July 18	Aug. 1
Undyed Bleach	52	43	39	40	36	33	27	25	23
Naphthol Dyed	49	45	42	36	32	26	22	21	18
Vat Dyed	48	45	43	40	36	31	25	24	21
D. and D. Dyed	51	43	44	43	38	32	29	28	23
Sulfur Dyed	51	40	44	45	41	35	33	30	26
Light-Fast Direct Dyed	46	44	43	43	39	32	29	27	23

Each break shown in this table is an average of eight breaks. April 24 reading represents after two weeks exposure.

Note that the April 24 reading for SULFUR DYED is very illogical and must he due to incomplete moisture regain before the breaks were made.

WEATHER CONDITIONS IN BIDDEFORD, MAINE (Cont.)

Date	Temperature 8.00 A.M.	Temperature 12.00 M.	Temperature 5.00 P.M.	Weather 8.00 A.M.	Weather 12.00 M.	Weather 5.00 P.M.	Rainfall	
8/13	64	82	80	C	C	C	0.00	
8/14	66	84	82	C	C	C	0.00	
8/15	68	84	82	C	C	C	0.00	
8/16	68	84	82	C	C	C	0.00	
8/17	68	84	82	C	C	C	0.00	
8/18	68	84	82	C	C	C	0.00	
8/19	68	84	82	C	C	C	0.00	
8/20	68	84	82	C	C	C	0.00	
8/21	68	84	82	C	C	C	0.00	
8/22	68	84	82	C	C	C	0.00	
8/23	68	84	82	C	C	C	0.00	
8/24	68	84	82	C	C	C	0.00	
8/25	68	84	82	C	C	C	0.00	
8/26	68	84	82	C	C	C	0.00	
8/27	68	84	82	C	C	C	0.00	
8/28	68	84	82	C	C	C	0.00	
8/29	68	84	82	C	C	C	0.00	
8/30	68	84	82	C	C	C	0.00	
8/31	68	84	82	C	C	C	0.00	
9/1	68	84	82	C	C	C	0.00	
9/2	68	84	82	C	C	C	0.00	
9/3	68	84	82	C	C	C	0.00	
9/4	68	84	82	C	C	C	0.00	
9/5	68	84	82	C	C	C	0.00	
9/6	68	84	82	C	C	C	0.00	
9/7	68	84	82	C	C	C	0.00	
9/8	68	84	82	C	C	C	0.00	
9/9	68	84	82	C	C	C	0.00	
9/10	68	84	82	C	C	C	0.00	
9/11	68	84	82	C	C	C	0.00	

Legend: X—Cloudy
C—Clear
H—Hazy
O—Overcast
D—Drizzle
R—Rain
S—Showers

(—) means slight.
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D. and D. Dyed	51	43	44	43	38	32	29	28	23
Sulfur Dyed	51	40	44	45	41	35	33	30	26
Light-Fast Direct Dyed	46	44	43	43	39	32	29	27	23

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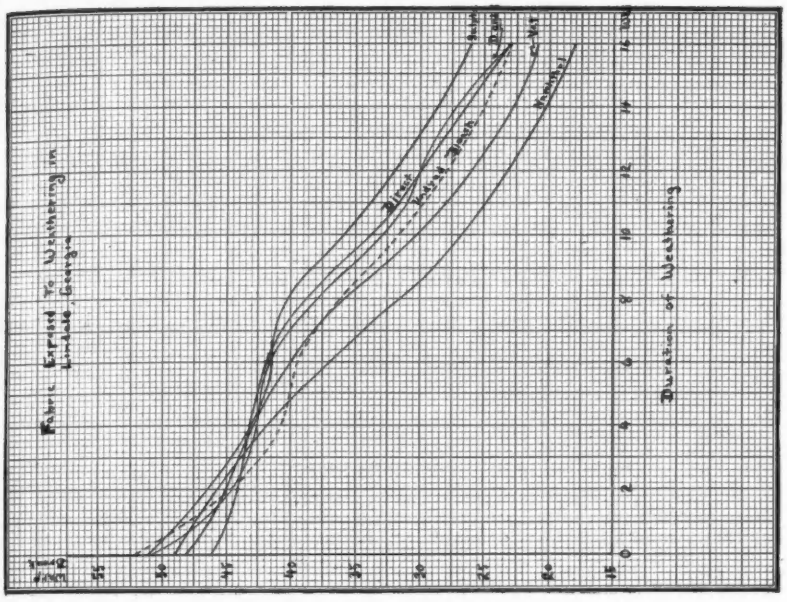


WEATHER CONDITIONS IN LINDALE, GEORGIA

Date	Temperature High	Temperature Low	Relative Humidity High	Relative Humidity Low
4/12/45	90	69	66	42
4/13	92	57	98	30
4/14	92	58	96	30
4/15	..	..	..	..
4/16	87	58	93	39
4/17	74	44	98	41
4/18	77	45	84	18
4/19	80	45	87	15
4/20	84	50	94	22
4/21	88	60	87	22
4/22	72	60	89	60
4/23	70	60	90	70
4/24	86	61	91	42
4/25	89	60	89	24
4/26	76	44	76	27
4/27	77	52	79	18
4/28	64	54	90	74
4/29	54	44	93	47
4/30	..	..	..	..
5/1	74	54	82	19
5/2	60	50	88	62
5/3	62	46	81	30
5/4	57	46	75	42
5/5/45	77	45	84	18
5/6	64	49	78	28
5/7	82	60	86	24
5/8	78	44	88	19
5/9	87	57	79	17
5/10	79	46	77	45
5/11	70	51	84	38
5/12	78	55	90	52
5/13	85	62	92	32
5/14	93	64	80	24
5/15	92	63	87	32
5/16	90	65	82	29
5/17	72	52	80	40
5/18	63	52	60	48
5/19	80	46	88	20
5/20	90	54	82	20
5/21	93	67	74	28
5/22	85	50	82	22
5/23	85	46	88	16
5/24	93	54	86	18
5/25	93	67	80	25
5/26	97	64	92	20
5/27	90	59	84	36
5/28/45	94	65	81	32
5/29	92	67	76	32
5/30	94	64	82	26
5/31	98	64	86	25
6/1	99	68	74	23
6/2	91	57	65	22
6/3	86	60	84	32
6/4	81	50	70	22
6/5	85	55	80	22
6/6	..	..	..	..
6/7	86	64	86	52
6/8	93	67	86	30
6/9	97	71	70	28
6/10	91	66	86	34
6/11	95	67	86	25

WEATHER CONDITIONS IN LINDALE, GEORGIA

Date	Temperature High	Temperature Low	Relative Humidity High	Relative Humidity Low
6/12	101	67	82	22
6/13	102	71	74	20
6/14	98	68	88	28
6/15	86	68	83	44
6/16	89	64	86	40
6/17	90	66	84	36
6/18	77	64	86	54
6/19	88	60	87	31
6/20/45	90	60	87	20
6/21	96	58	82	20
6/22	97	62	82	17
6/23	102	69	83	18
6/24	100	69	80	24
6/25	96	69	79	20
6/26	98	68	80	24
6/27	103	70	80	21
6/28	103	71	79	24
6/29	104	71	78	25
6/30	102	71	71	30
7/1	101	69	85	24
7/2	92	63	67	34
7/3	93	70	78	30
7/4	100	70	72	24
7/5	90	70	84	42
7/6	95	66	86	24
7/7	96	66	78	20
7/8	101	72	68	20
7/9	96	74	82	29
7/10	98	70	74	28
7/11	94	59	74	20
7/12	94	76	74	22
7/13/45	88	70	76	43
7/14	92	70	80	28
7/15	90	64	68	35
7/16	95	68	70	18
7/17	96	68	79	27
7/18	96	70	74	27
7/19	98	70	78	25
7/20	99	67	82	25
7/21	100	70	74	24
7/22	102	72	76	24
7/23	105	73	66	25
7/24	106	76	62	24
7/25	97	70	75	32
7/26	93	73	70	33
7/27/45	99	72	74	30
7/28	92	73	79	40
7/29	86	71	68	50
7/30	97	70	80	28
7/31	100	70	80	28
8/1	96	75	70	30
8/2	98	71	87	35
8/3	104	72	74	22
8/4	100	73	76	22
8/5	95	72	72	26
8/6	97	72	76	28
8/7	88	69	76	40
8/8	92	66	66	20

Temperature and Relative Humidity readings were taken from Bristol Recorder charts.

WEATHER CONDITIONS IN LINDALE, GEORGIA

Date	Av. Weather During Day	Rainfall
4/10/45	Clear	0.00
4/11	Clear	0.00
4/12	Clear	0.00
4/13	Clear	0.00
4/14	Clear	0.00
4/15	....	0.00
4/16	Cloudy, rain	0.10
4/17	Clear	0.00
4/18	Clear	0.00
4/19	Clear	0.00
4/20	Clear	0.00
4/21	Clear	0.00
4/22	Cloudy, rain	1.05
4/23	Cloudy, rain	0.40
4/24	Cloudy, rain	1.69
4/25	Clear	0.00
4/26	Clear	0.00
4/27	Clear	0.00
4/28	Cloudy, rain	1.60
4/29	Cloudy	0.00
4/30	Clear	0.00
5/1	Cloudy	0.00
5/2	Cloudy, rain	0.76
5/3/45	Cloudy	0.00
5/4	Cloudy, rain	0.02
5/5	Cloudy	0.00
5/6	Rain	0.09
5/7	Clear	0.00
5/8	Clear	0.00
5/9	Clear	0.00
5/10	Clear	0.00
5/11	Cloudy, rain	1.18
5/12	Cloudy, rain	0.65
5/13	....	0.00
5/14	Clear	0.00
5/15	Cloudy, rain	1.20
5/16	Cloudy	0.00
5/17	Cloudy	0.00
5/18	Clear	0.00
5/19	Clear	0.00
5/20	Clear	0.00
5/21	Clear	0.00
5/22	Clear	0.00
5/23	Clear	0.00
5/24	Clear	0.00
5/25	Cloudy, rain	0.38
5/26/45	Clear	0.00
5/27	Clear	0.00
5/28	Clear	0.00
5/29	Clear	0.00
5/30	Clear	0.00
5/31	Clear	0.00
6/1	Clear	0.00
6/2	Cloudy, rain	0.07
6/3	Clear	0.00
6/4	Clear	0.00
6/5	Clear	0.00
6/6	Clear	0.00
6/7	Cloudy, rain	0.32
6/8	Clear	0.00
6/9	Cloudy, rain	Trace
6/10	Cloudy, rain	0.11
6/11	Clear	0.00
6/12	Clear	0.00
6/13	Clear	0.00
6/14	Clear	0.00
6/15	Cloudy, rain	0.23
6/16	Clear	0.00
6/17	Cloudy, rain	0.97
6/18/45	Cloudy	0.00
6/19	Cloudy, rain	0.83
6/20	Clear	0.00
6/21	Clear	0.00
6/22	Clear	0.00
6/23	Clear	0.00
6/24	Clear	0.00
6/25	Clear	0.00
6/26	Clear	0.00
6/27	Clear	0.00
6/28	Clear	0.00
6/29	Clear	0.00
6/30	Clear	0.00
7/1	Clear	0.00
7/2	Clear	0.00
7/3	Clear	0.00
7/4	Clear	0.00
7/5	Clear	0.00
7/6	Clear	0.00
7/7	Clear	0.00
7/8	Clear	0.00
7/9	Clear	0.00
7/10	Shower	0.03
7/11/45	Clear	0.00
7/12	Clear	0.00
7/13	Cloudy, rain	0.95
7/14	Cloudy, rain	1.56
7/15	Clear	0.00
7/16	Clear	0.00
7/17	Clear	0.00

WEATHER CONDITIONS IN LINDALE, GEORGIA

Date	Av. Weather During Day	Rainfall
7/18	Cloudy, rain	1.28
7/19	Clear	0.00
7/20	Clear	0.00
7/21	Clear	0.00
7/22/45	Clear	0.00
7/23	Clear	0.00
7/24	Clear	0.00
7/25	Clear	0.00
7/26	Clear	0.00
7/27	Clear	0.00
7/28	Clear	0.00
7/29	....	0.00
7/30	Cloudy, rain	0.71
7/31	Clear	0.00

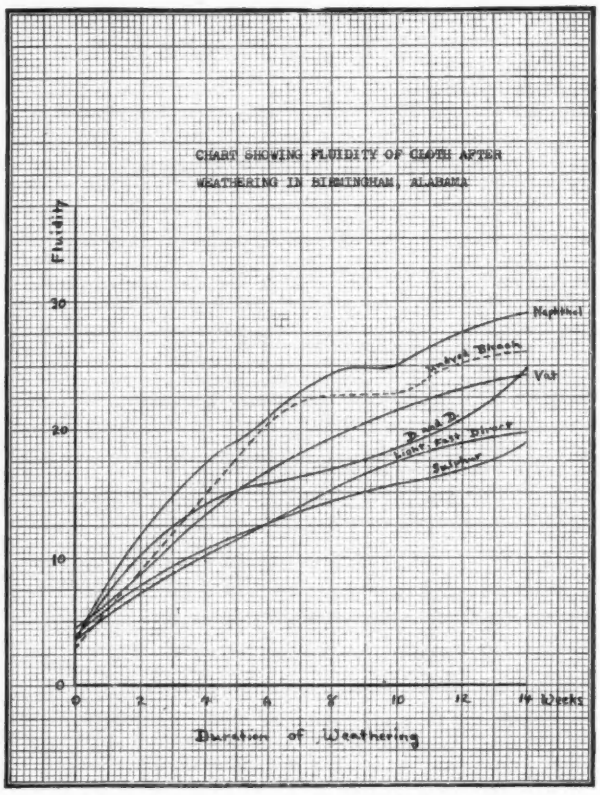
The above information was furnished by Pepperell Mfg. Co., Lindale, Georgia.

FLUIDITY READINGS SHOW DEGRADATION OF EXPOSED FABRIC

Fluidity determinations were made on samples of exposed cloth covering the entire 14 week period of exposure in Birmingham, Alabama. Determinations were also made on cloth exposed at Biddeford, Maine, and Lindale, Georgia, showing degradation after 14 weeks exposure.

The fluidities given were determined by the A.S.T.M. Method published in *A.S.T.M. Standards* of October, 1944, page 160 (D539-40T). Some modifications were made for the purpose of simplifying the work. Essentially the fluidity is measured by determining the viscosity of a 0.5% cellulose solution in cuprammonia containing 15 g. of copper per liter and 200 g. of ammonia.

Each figure in the tables which follow represents an average of two separate complete determinations.



VARIATION OF FLUIDITY WITH EXPOSURE

Fabric	Unexposed Original	2-14 Weeks at Birmingham, Ala. 2	4	6	8	10	12	14
Undyed Bleach	3.1	8.8	15.2	20.5	22.7	22.8	25.1	26.0
Naphthol Dyed	3.7	12.6	16.8	20.8	24.4	25.0	27.5	29.0
Vat Dyed	4.7	8.8	13.6	16.7	19.2	20.9	23.4	24.1
D. and D. Dyed	3.5	10.8	13.3	15.6	16.9	19.3	19.8	24.8
Sulfur Dyed	3.7	8.2	10.3	12.3	14.1	15.8	16.3	19.2
Light-Fast Direct Dyed	3.4	7.1	9.9	13.0	14.3	17.8	18.6	19.9

FLUIDITY COMPARISONS AFTER 14 WEEKS EXPOSURE

Fabric	Unexposed Original	14 Weeks Birmingham	14 Weeks Biddeford	14 Weeks Lindale
Undyed Bleach	3.1	26.0	29.4	28.3
Naphthol Dyed	3.7	29.0	29.4	29.3
Vat Dyed	4.7	24.1	24.4	27.9
D. and D. Dyed	3.5	24.8	25.1	26.4
Sulfur Dyed	3.7	19.2	22.5	23.6
Light-Fast Direct Dyed	3.4	19.9	23.2	25.3

SPECTROPHOTOMETRIC EVALUATION

In order to determine the degree of fading sustained during exposure, the cloth samples that had been exposed in Birmingham were checked with a Spectrophotometer.

The spectrophotometric data was interpreted so that it may be translated into per cent color remaining after weather exposure with full allowance for the dirt accumulated by the samples during weather exposure. Thus, the net result reported discounts the dirt accumulation factor and separates it from color destruction value.

The method employed takes average spectrophotometric reflectance measurements at the wave length of maximum absorption on the faded samples as well as on the white controls exposed to weather for the various periods. By using the K/S relationship, which is explained in detail in Mr. Seibert's article appearing in the *American Dyestuff Reporter* for the week of July 2, 1945, values were obtained for the dyed fabric plus dirt and for the undyed fabric plus dirt. The difference between these two represents the K/S value for the dyestuff. Since K/S is approximately proportional to the concentration of dyestuff, the percentage of color remaining on the fabric at the different periods of exposure is shown directly. These data are listed in the following tables.

FABRIC DYED WITH NAPHTHOL DYESTUFF

	White Fabric plus Dirt		Blue Fabric, Dirt, Dye		Actual Dye	
	Reflectance	K/S	Reflectance	K/S	K/S	% Dye
Unexposed	83.0	.0174	2.0	24.01	23.99	100.0
April 14	58.0	.152	7.5	5.704	5.552	23.3
April 28	49.8	.253	20.6	1.530	1.277	5.3
May 12	44.8	.340	30.8	.777	.437	1.83
May 26	41.0	.420	34.5	.622	.102	.425
June 9	38.0	.506	37.4	.524	.018	.075
June 23	37.2	.530	36.7	.546	.016	.067
July 7	37.0	.536	37.0	.536	.000	.000

Readings before May 12 at 590 millimicrons; after May 12 at 580 millimicrons.
April 14 reading represents after two weeks exposure. Fabric exposed at Birmingham, Alabama.

FABRIC DYED WITH VAT DYESTUFF

	White Fabric plus Dirt		Blue Fabric, Dirt, Dye		Actual Dye	
	Reflectance	K/S	Reflectance	K/S	K/S	% Dye
Unexposed	82.2	.0193	3.6	12.907	12.88	100.0
April 14	57.3	.159	3.7	12.532	12.373	96.2
April 28	49.3	.261	4.6	9.893	9.632	75.4
May 12	44.4	.348	5.8	7.650	7.302	56.8
May 26	38.0	.506	7.9	5.369	4.863	38.0
June 9	34.9	.607	12.2	3.159	2.552	19.9
June 23	32.3	.709	15.3	2.344	1.069	8.36
July 7	30.4	.797	21.3	1.454	.657	5.14

Readings at 565 millimicrons.
April 14 reading represents after two weeks exposure.
Fabric exposed at Birmingham, Alabama.

FABRIC DYED WITH DIAZOTIZED AND DEVELOPED DYESTUFF

	White Fabric plus Dirt		Blue Fabric, Dirt, Dye		Actual Dye	
	Reflectance	K/S	Reflectance	K/S	K/S	% Dye
Unexposed	82.5	.0186	3.3	14.168	14.149	100.0
April 14	57.4	.158	4.3	10.649	10.491	73.6
April 28	49.4	.259	8.8	4.726	4.467	31.7
May 12	44.6	.344	15.6	2.283	1.939	13.6
May 26	38.6	.488	29.8	.827	.339	2.4
June 9	36.0	.569	28.8	.880	.311	2.2
June 23	34.6	.618	30.0	.817	.199	1.41
July 7	33.4	.664	33.4	.664	.000	.000

Readings at 570 millimicrons.
April 14 reading represents after two weeks exposure.
Fabric exposed at Birmingham, Alabama.

FABRIC DYED WITH SULFUR DYESTUFF

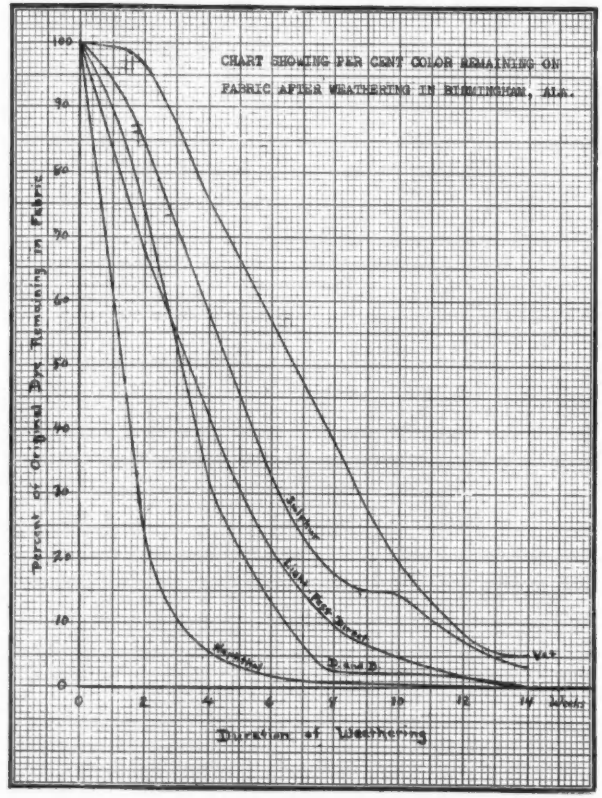
	White Fabric plus Dirt		Blue Fabric, Dirt, Dye		Actual Dye	
	Reflectance	K/S	Reflectance	K/S	K/S	% Dye
Unexposed	82.6	.0183	3.3	14.168	14.150	100.0
April 14	57.8	.154	3.8	12.177	12.023	84.6
April 28	49.7	.255	5.3	8.460	8.205	57.8
May 12	44.9	.338	8.4	4.994	4.656	32.7
May 26	39.8	.455	12.8	2.970	2.515	17.7
June 2	36.2	.562	13.9	2.667	2.105	14.8
June 23	33.3	.668	19.1	1.713	1.045	7.34
July 7	30.7	.782	22.8	1.307	.525	3.69

Readings at 580 millimicrons.
April 14 reading represents after two weeks exposure.
Fabric exposed at Birmingham, Alabama.

FABRIC DYED WITH LIGHT-FAST DIRECT DYESTUFF

	White Fabric plus Dirt		Blue Fabric, Dirt, Dye		Actual Dye	
	Reflectance	K/S	Reflectance	K/S	K/S	% Dye
Unexposed	83.0	.01741	3.5	13.303	13.286	100.0
April 14	58.3	.149	5.0	9.025	8.876	67.2
April 28	50.1	.234	7.4	5.794	5.560	42.3
May 12	45.4	.328	12.1	3.193	2.865	21.7
May 26	41.2	.420	19.0	1.727	1.307	9.78
June 9	38.0	.506	24.4	1.171	.665	5.0
June 23	36.1	.566	30.6	.787	.221	1.66
July 7	33.3	.668	33.3	.668	.000	.000

Readings at 600 millimicrons.
April 14 reading represents after two weeks exposure.
Fabric exposed at Birmingham, Alabama.



ACCELERATED WEATHERING AND FADING TESTS

In this section an attempt was made to draw a comparison between such accelerated tests and actual outdoor results. In making these tests an Atlas Weather-Ometer and an Atlas Fade-Ometer were used.

The study was divided into two types of tests. In the first, several 4" x 6" samples from each type of dyed cloth, and also the bleached control, were exposed in a Twin Arc Weather-Ometer for periods of from 20 to 450 hours. The cycle selected was the one accepted by the textile group known as 51-9, meaning 51 minutes of uninterrupted light from two arcs, followed by 9 minutes of fine water spray (rain) at 0.215 pints of water spray on each specimen every minute during the spray period. This means 9 minutes of spray every hour during exposure.

The temperature maintained during the entire test was 110-115 F Ambient and 145-150 F on a black panel thermometer. This black panel thermometer consists of a stainless steel panel 0.032 gauge to which surface (100 square cm) is clamped a Weston Dial Thermometer. This stainless steel panel and the active portion of the thermometer is covered with two coats of dull black enamel baked on, to 225 F.

All weathering specimens were cut 4" x 6" and mounted under very slight tension on red cedar frames.

The 51-9 weathering cycle was used throughout the test.

In the second type of test which deals with fading, a type FDA-R Fade-Ometer was used. Exposures were made in duplicate for periods of 150, 300, and 450 hours on all dyed samples.

The Fade-Ometer was operated at 230 volts a.c., and 15-17 amperes.

The ambient temperature was 105 F. The relative humidity was 30 to 40 per cent.

The following tables show the results of these tests in a very clear manner. In addition, these tables also bring out the relative rates of color fading that took place in the actual weathering tests that were conducted at Biddeford, Birmingham, and Lindale in which the cloth was exposed to outdoor conditions.

WEATHER-OMETER RESULTS COMPARED TO ACTUAL WEATHERING

Type Dyeing	Weather-Ometer Tests: Hrs. in Weather-Ometer	No. of Samples Broken	Av. Warp Break	Actual Weeks of Outdoor Exposure that Produced an Equivalent Color Fading: At Birmingham	At Lindale	At Biddeford
BLEACHED: Control	Unexposed	2	44	..	..	..
	100	1	38	..	..	..
	120	1	37	..	..	..
	200	1	32	..	..	..
	450	2	28	..	..	..
NAPHTHOL:	Unexposed	2	40	..	..	..
	20	1	36	4	4	4½
	100	2	31	10	10	10
	200	1	33	14	14	14
	450	3	22	14	14	14
VAT:	Unexposed	2	40	..	..	..
	100	1	40	2	2	2
	120	1	40	4	4	4
	200	1	35	10	8	10
	450	4	18	14	12	14
DIAZOTIZED: and DEVELOPED	Unexposed	2	42	..	..	..
	100	1	40	3	3	4
	120	1	40	4	4	5
	200	1	40	6	5	8
	450	2	28	14	14	14
SULFUR:	Unexposed	2	38	..	..	..
	100	1	..39	4	4	5
	120	1	36	6	5½	8
	200	1	34	12	11	13
	450	2	25	14	12	14
LIGHT-FAST DIRECT	Unexposed	2	40	..	..	..
	100	2	40	2	2	2
	120	1	36	4	3	6
	200	2	37	6	5	7
	450	2	32	14	14	14

FADE-OMETER RESULTS COMPARED TO ACTUAL WEATHERING

Type Dyeing	Hours in Fade-Ometer	Actual Weeks of Outdoor Exposure that Produced an Equivalent Color Fading: At Birmingham	At Lindale	At Biddeford
NAPHTHOL:	150	3	3	3½
	300	6	6	6½
	450	10*	10*	10*
VAT:	150	2	2	2
	300	4	4	4
	450	6	5	6
DIAZOTIZED: and DEVELOPED	150	3	3	4
	300	6	5	8
	450	10*	8*	11*
SULFUR:	150	4	4	5
	300	6	5½	8
	450	8	8	11
LIGHT-FAST: DIRECT	150	4	3	6
	300	7*	6*	7½*
	450	10*	8*	10*

* It was difficult to be sure of these particular numbers since in the Fade-Ometer the fading went yellow. This was not the case in samples exposed to actual weathering.

ACCELERATED AGING TESTS

Accelerated Aging Tests were made on each of the six samples of cloth. The procedure used followed the standard A.A.T.C.C. procedure for conducting such tests on sulphur dyed material. The set of samples that was heated for one hour was put in an oven and heated for one hour at 275 F. without the addition of any water.

On the set of samples run for two hours, the oven was kept at 275 F. for one hour and then 50 cc. of water—or 20 cc. of water for each cubic foot capacity of the oven—was added at the beginning of the second hour. The heating was conducted for a total of two hours.

The set of samples heated for three hours was run in a like manner and the 50 cc. of water was added at the beginning of the second and third hours.

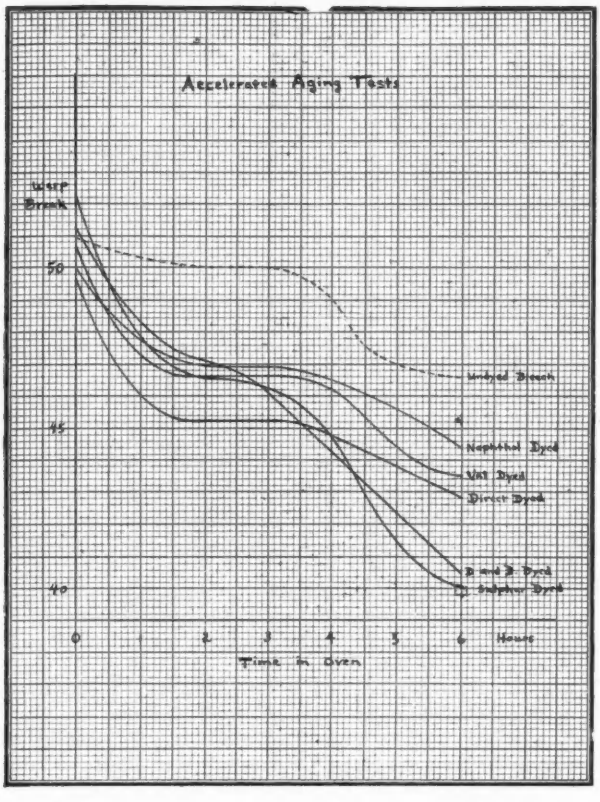
The samples heated for four, five, and six hours were likewise run similarly with water additions at the end of each hour of heating except the final hour.

The results of these tests are given in the following table.

RESULTS OF ACCELERATED AGING

Fabric	Original Not Aged	Warp Break After Aging 1-6 Hours: 1 Hr.	2 Hrs.	3 Hrs.	4 Hrs.	5 Hrs.	6 Hrs.
Undyed Bleach	51.0	50.3	50.0	50.0	47.1	47.6	46.6
Naphthol Dyed	49.9	47.3	46.6	48.1	47.0	45.3	44.5
Vat Dyed	50.5	46.3	46.6	47.1	46.1	43.8	43.5
D. and D. Dyed	51.2	47.1	47.5	46.1	44.3	42.1	40.5
Sulfur Dyed	52.1	47.8	46.6	45.8	44.8	40.0	40.4
Light-Fast Direct Dyed	49.6	46.0	45.3	45.3	44.8	43.8	42.8

Each break shown in this table is an average of six breaks.



CONCLUSIONS

In general the charts and tables in this Paper show the following facts to be true.

(1) Warp-break tests show that the Naphthol dyed fabric deteriorated more rapidly than did the undyed bleach.

(2) Similar tests demonstrated that cloth dyed with sulphur, light-fast direct, and diazotized and developed type dyestuffs possessed a resistance to deterioration greater than the undyed bleach.

Vat dyed cloth was about equal to, or, slightly more resistant to deterioration than the undyed bleach.

(3) Viscosity determinations on the Birmingham samples confirm the results obtained by warp-breaks.

In studying the viscosity tables it is well to keep in mind the fact that a greater fluidity figure denotes a thinner liquid and more deterioration of the fabric.

(4) There does not seem to be any mathematical relationship between fabric deterioration from weathering and the color fading that takes place. A glance at the following chart will show this.

SPECIAL MENTION

In addition to the Committee, the following individuals and firms were largely responsible for work done on this paper as noted. We express our appreciation to each.

The Russell Manufacturing Company, Alexander City, Alabama, for dyeing cloth samples used in these tests.

Pepperell Manufacturing Company at Biddeford, Maine and Lindale, Georgia; also Avondale Mills at Birmingham, Alabama, for exposing cloth samples to Weather.

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Edgar C. Horton of The Birmingham Weather Bureau.

Fabric Exposed to Outdoor Weathering in Birmingham for a Duration of 2 to 14 Weeks

	2 Wks. %	4 Wks. %	6 Wks. %	8 Wks. %	10 Wks. %	12 Wks. %	14 Wks. %
Undyed BLEACH:							
% loss in warp strength.....	12	21	27	35	41	45	57
NAPHTHOL dyed							
% loss in warp strength.....	10	17	29	37	48	56	65
% loss in color.....	76.7	94.7	98.2	99.6	99.9	99.9	100
VAT dyed							
% loss in warp strength.....	6	10	19	25	35	45	57
% loss in color.....	3.8	24.6	43.2	62.0	80.1	91.6	94.9
D. & D. dyed							
% loss in warp strength.....	11	18	27	31	33	36	60
% loss in color.....	26.4	68.3	86.4	97.6	97.8	98.6	100
SULPHUR dyed							
% loss in warp strength.....	3	7	14	16	25	30	41
% loss in color.....	15.4	42.2	67.3	82.3	85.2	92.7	96.3
LIGHT-FAST DIRECT dyed							
% loss in warp strength.....	2	6	13	18	32	34	41
% loss in color.....	32.8	57.7	78.3	90.2	95.0	98.3	100

The per cent loss in warp strength was calculated from the values found in the table on Warp Breaks after Weathering in Birmingham. The per cent loss in color was calculated from the tables of Spectrophotometric data from cloth after Weathering in Birmingham.

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Intersectional Contest—

SOME EFFECTS OF DRY HEAT UPON THE PROPERTIES OF NYLON FABRICS*

COMMITTEE
Philadelphia Section
ARTHUR W. ETCHELLS
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SYLVESTER AUMULLER
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Paper Presented by
ARTHUR W. ETCHELLS

Presented by the
PHILADELPHIA SECTION

NYLON fabrics can be greatly improved in handle and appearance by heat treating. These heat treated fabrics are softer, more mellow, and have a finished appearance not apparent in untreated materials.

Heat treating also renders the fabric more resistant to dimensional changes, and also helps to overcome the tendency to crease when washed or submitted to other wet treatments.

Properly "heat treated" nylon fabrics may be dyed in rope form at elevated temperatures without developing crow's feet or dye creases, which are unavoidable in untreated fabrics.

Pieces "set" at high temperatures are also more resistant to creasing when dry, and, if creased, quickly recover to the normal uncreased state when allowed to relax.

A further advantage of heat treating nylon fabrics is that many of the strains accumulated in the manufacturing of the fabric are equalized and thus produce a more satisfactory piece of material.

It has also been observed that heat treated nylon fabrics do not always show the same dye affinity that is shown by untreated nylon, and it is well known that nylon can be severely damaged by heat.

With these advantages and disadvantages in mind, this study was undertaken in order to determine the best operating conditions for securing the maximum number of advantages with the least amount of damage to the nylon, and also to determine the effect of heat treating upon the dyeing properties of the fiber.

The first trial was made by passing measured pieces of nylon parachute fabric over an electrically heated revolving cylinder, varying the temperature through the range of 335°F.-470°F., but maintaining a constant contact time of 2½ seconds during the treatment. It should be noted at this point that he goods were drawn over the cylinder and batched onto a shell, and although the cylinder was driven, there was considerable warpwise tension.

The second test was made using apparatus described in the first trial, but maintaining a temperature of 440°F.-450°F., and varying the contact time from 2½ seconds to 13 seconds. The temperature of 440°F.-450°F. was chosen because it was tne maximum safe temperature at 2½ seconds contact time, and we wished to study the effect of increased time of exposure.

The fabric was, as in the first test, held under tension.

To eliminate the tension variable, a third group of samples was treated in an oven capable of taking one yard squares of fabric and in which the temperature could be closely controlled. In the oven the fabric was supported, at full width, upon a wire screen, and heated air was drawn through the material, which was allowed to shrink freely in all directions.

Temperatures of 300, 350, 400, 450 and 470°F. were used, and exposure times were 5, 10 and 15 seconds at each temperature.

In all of the tests, measurements of both warp and filling were made before and immediately after exposure. Another measurement was made after conditioning the fabric for 48 hours in order to ascertain the amount of shrinkage after treatment and also the amount of creep, because it was noted that the treated fabrics tended to return to the original dimensions. This tendency ceased after 48 hours, and measurements made at a later date showed little or no change.

The fabrics after heat treating were tested for tensile strength, and the elongation at the breaking point was also determined for both warp and filling, the loss in strength being a good indication of the amount of damage suffered by the nylon. (These tests were made on one inch strips on a Scott Tester.)

The dyeing trials were made using ½ per cent dyestuff at 185°F. for 1 hour. Acetic acid was used with the acid dyes. A piece of untreated nylon was included in each set of dyeings as a control. Samples in each series were all dyed together in the same beaker.

Four types of blue dyestuffs were used:

1. An Acid Anthraquinone dye—Brilliant Alizarine Blue B. S. (Sandoz)
2. An Acid Azo color, represented by—Cloth Fast Blue R (Ciba)
3. An Anthraquinone Acetate type—Celanese Pure Blue B (American Aniline)
4. An Azo Acetate dyestuff—Eastone Blue B. G. F. (Eastman)

Attempts were also made to dye the fabric with Pontamine Sky Blue 6B—a color which does not normally dye nylon—in the hope that heat treated fabrics might have an increased affinity for direct colors, but such was not the case and very little coloration was produced upon the fabric.

TEST NO. 1

This fabric was heat treated at constant time, variable temperatures.

Chart I.

This graph shows the shrinkage plotted in inches against the temperature of pretreatment. The filling, which is under but little tension in processing, shows a loss in width at 470°F. of 1½ inches, with no creep back to the original width of 37 inches. Goods treated at 445°F. also show a permanent fixation.

At lower temperatures the goods show a uniform tendency to return to the original dimensions, although in no case did the fabric return to the original width.

The warp, which was held under tension, shows practically no variation in length.

Chart II.

This graph shows the loss in strength of the filling when exposed to varying temperatures, the greatest loss occurring between 435°F.-470°F. The warp shows but little loss in strength throughout the range of temperatures used.

Chart III.

This chart, showing the per cent elongation, indicates that the filling elongation is not seriously affected by temperatures up to 445°F. Over that temperature there is a distinct loss. Both this curve and the warp curve follow the same general course as the tensile strength curves.

All of these tests indicate that nylon fabrics may be exposed to dry heat at tem-

* Presented at Intersectional Contest, Victory Convention, Hotel Pennsylvania, New York City, January 5, 1946.

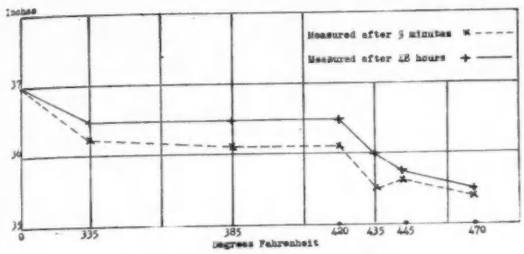

Chart I. Nylon Filling Shrinkage - Contact Time 2½ Seconds
Measurement Before Treating 37 Inches.

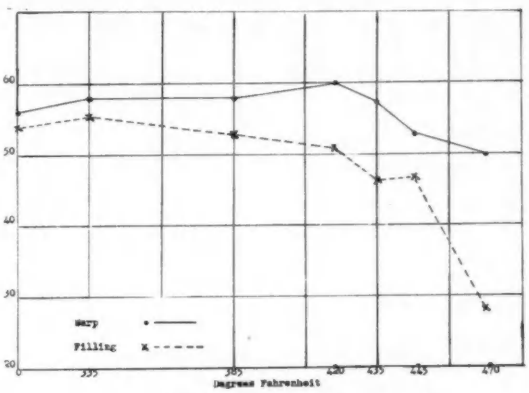

Chart II. Nylon Tensile Strength - Contact Time 2½ Seconds
Tension on Warp

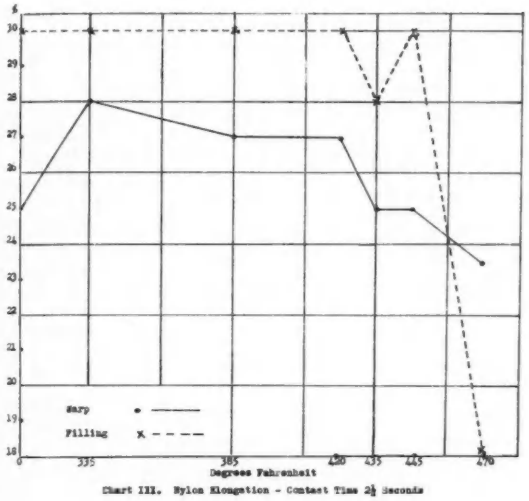

Chart III. Nylon Elongation - Contact Time 2½ Seconds

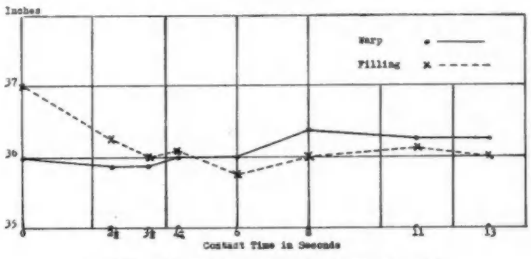

Chart IV. Nylon Shrinkage - Temperature 440-450° Fahrenheit
Tension on Warp

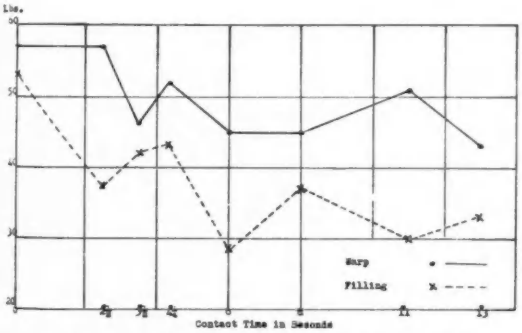

Chart V. Nylon Tensile Strength - Temperature 440-450° Fahrenheit

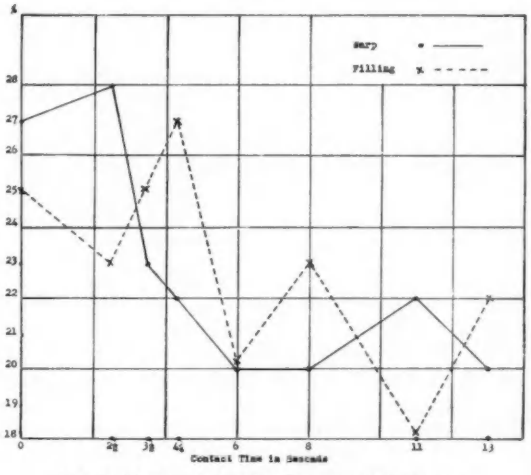

Chart VI. Nylon Percent Elongation - Temperature 440-450° Fahrenheit

peratures of 335°F.-440°F. for 2½ seconds without serious damage to the nylon. Higher temperatures of treatment cause rapid degradation of the fiber.

Chart IV.

This shows the effect of operating at the highest safe temperature and varying the time of contact.

Contact times used were 2½, 3½, 4¼, 6, 8, 11 and 13 seconds. There is practically no warp shrinkage, whereas the filling shows nearly maximum shrinkage at the shortest exposure time, with very little change thereafter.

Chart V.

This shows the loss in tensile strength caused by increasing the time of contact of the fabric with the heated cylinder. Both warp and filling show a constant reduction in strength.

Chart VI.

In this graph the warp shows a consistent loss in elongation with increased contact time, a fact which would be expected under the conditions of operation; i.e., heating the fabric while under tension.

The filling gives a very erratic line, the reason for which we have not been able to find.

Charts VII, VIII, IX.

These demonstrate the effect of dry heat upon the relaxed fabric where the goods were allowd to shrink freely in all directions. All three graphs show the same general type curves and indicate an appreciable creep back to the original dimensions after conditioning for 48 hours.

Charts X, XI, XII.

The above charts show the effect of exposure time upon the tensile strength of the nylon. It is worthy of note that the

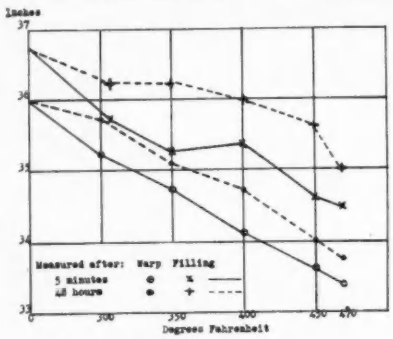

Chart VII. Nylon Shrinkage - 5 Seconds Exposure

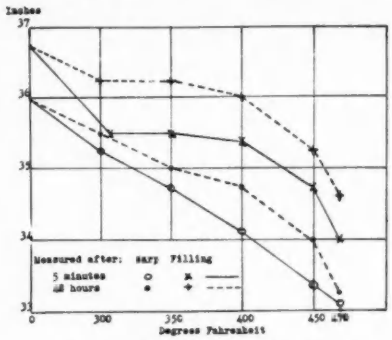

Chart VIII. Nylon Shrinkage - 10 Seconds Exposure

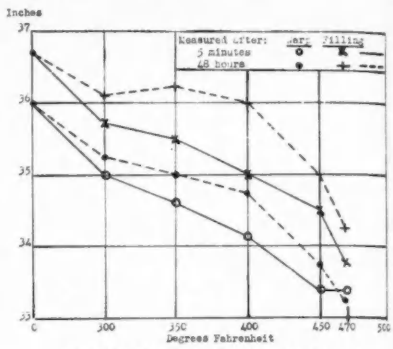

Chart IX. Nylon Shrinkage - 15 Seconds Exposure

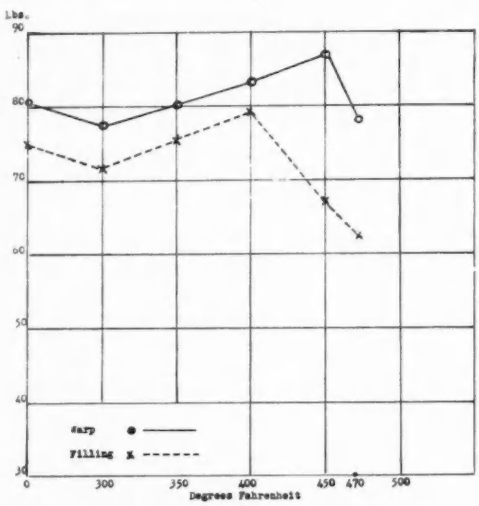

Chart X. Nylon Tensile Strength. Heat applied to relaxed material allowing free shrinkage in both directions. Treated for 5 seconds.

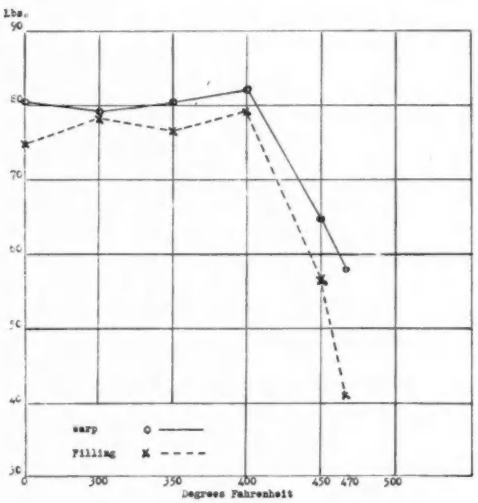

Chart XI. Nylon Tensile Strength. Heat applied to relaxed material allowing free shrinkage in both directions. Treated for 10 seconds.

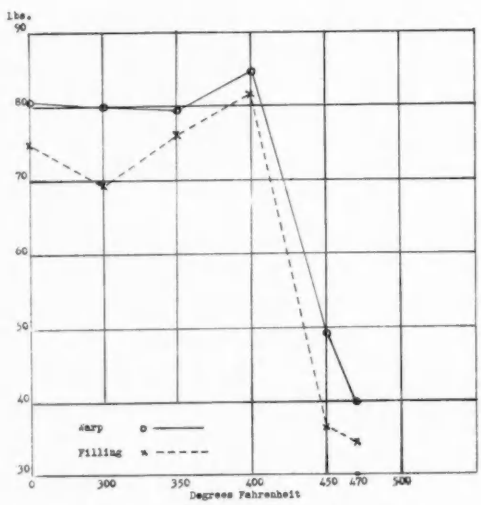

Chart XII. Nylon Tensile Strength. Heat applied to relaxed material allowing free shrinkage in both directions. Treated for 15 seconds.

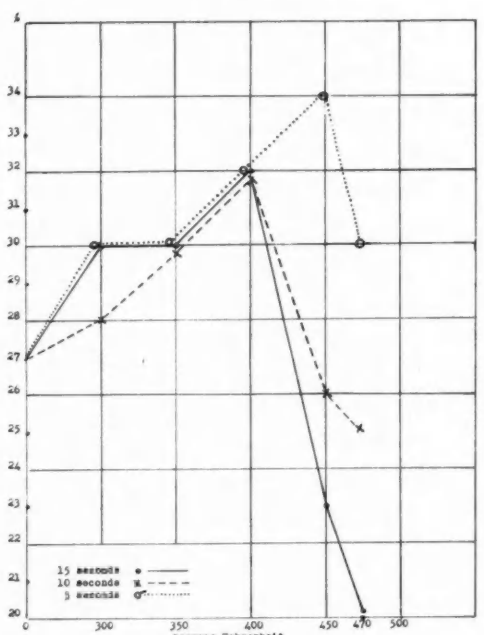

Chart XIII. Nylon Warp Elongation - Fabric Heat Treated in Relaxed State

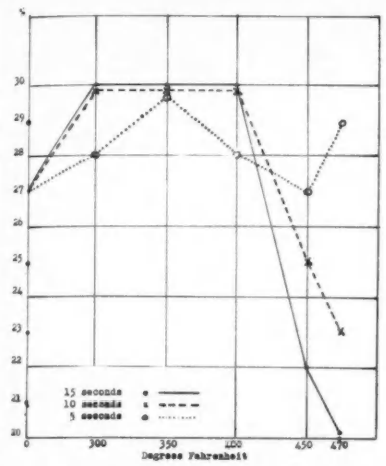

Chart XIV. Nylon Filling Elongation - Heated in Relaxed State

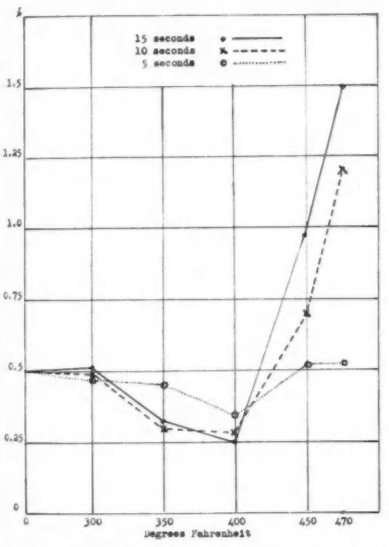

Chart XVI. Dyeings of Cloth F. Blue R - Heated in Relaxed State Control 0.5% Dyestuff on Untreated Nylon

5-second exposure time probably is too short a time to allow the goods to come to equilibrium with the heated air, and therefore shows less loss in strength. The exposures for 10 and 15 seconds show a great loss in strength at temperatures of over 400°F.

Charts XIII, XIV.

They indicate that due to the shrinkage of the fabric, the elongation increases. Then at 400°F., where degradation of the nylon begins, the elongation drops sharply. Again it is indicated that 5 seconds exposure time is not sufficient for the goods to come to equilibrium.

DYEING TRIALS

TEST NO. 1

Constant contact time; temperature varied from 335°F.-470°F. Dyeings made with Brilliant Alizarine Sky Blue B. S. These samples were all dyed together in the same beaker, and an untreated piece of nylon was also included as a control.

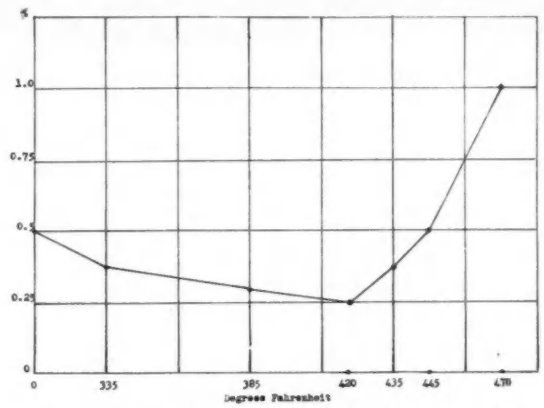

Chart XV. Dyeings of Cloth F. Blue R - Control 0.5% Dyestuff on Untreated Nylon

Samples pretreated at 420°F.-445°F. show no creases after dyeing and air drying; in fact, they appear as if they were pressed, but the samples treated at the lower temperatures have heavy creases. (This applies to all dyeings in this series.)

These dyed samples show no significant difference in shade, with the exception of the sample heat treated at 470°F., which is much greener and duller. This is caused by the yellowing of the nylon at the higher temperatures of pretreatment.

Chart XV.

Dyeings made with Cloth Fast Blue R, and Azo Acid dye, show very great differences in the depth of shade. The above chart shows graphically these differences. There is a decrease in dye take-up with increasing temperature of pretreatment up to 420°F.; then the dye absorption increases with increasing degradation of the nylon.

Pieces dyed with Celanese Pure Blue B, an acetate dyestuff of the Anthraquinone group show a progressive loss in depth of color with increased temperature of pretreatment. The samples treated at the higher temperatures (over 420°F.) are also much greener and duller.

Heat treated samples dyed with Eastone Blue B. G. F. show decreasing absorption of color with increase in the temperature of pretreatment. The samples treated at over 420°F. are also duller and greener.

In the series heat treated at 440°F.—450°F., and changing the time of contact of the fabric with the cylinder, through the range of 2½ seconds to 13 seconds only, the untreated control showed creases after dyeing in a beaker and air dying. All of the other samples presented a smooth, flat surface equivalent to a well pressed fabric.

The Anthraquinone Acid dye, Brilliant Alizarine Sky Blue B. S., when dyed on these samples showed a slight loss in depth from the greatest exposure time to the least exposure time.

The Azo Acid dye, Cloth Fast Blue R, showed very little difference over the same range, with a slight increase in depth of color in the samples treated for the longer time.

The Anthraquinone Acetate dyestuff, Celanese Pure Blue B, when dyed on the heat treated samples, was progressively lighter, greener and duller with increased time of contact.

The Azo Acetate dye, Eastone Blue B. G. F., also showed decreased absorption with increased time of contact, the samples with the longest contact time being much lighter and greener, and the sample pretreated for the longest time being about one-half the shade of the untreated control.

The samples heat treated in the relaxed state show greater differences in the dyed samples than material heated by contact with the metal cylinder.

Chart XVI.

This graph indicates the large differences in depth of color caused by heat treating without tension on the fabric. There is first a decrease in dye absorption when using Cloth Fast Blue R; then with increasing degradation of the nylon, a very great increase, amounting to about three times that of the 0.5% dyeing on the untreated control. This chart also indicates that the time of exposure to the heat treatment has a great effect on the dye absorption. At 400°F.—the point at which the tensile strength of the nylon starts to decrease—the dye absorption increases. (This dyestuff, Cloth Fast Blue R, should be of value in determining the amount of damage done to nylon by heat.)

Chart XVII.

As illustrated, the acid dye Brilliant Alizarine Sky Blue B shows a decrease in the depth of color on the fabric with in-

Chart XVII. Brilliant Alizarine Sky Blue B. S.

	Temperature of Pretreatment	Time of Pretreatment	Appearance after Dyeing
Least color on the fabric	400° F.	15 seconds	Not Creased
	350	15 seconds	Not Creased
	325	10 seconds	Not Creased
	400	5 seconds	Not Creased
	350	5 seconds	Creased
	300	15 seconds	Creased
	350	10 seconds	Slightly Creased
	300	10 seconds	Slightly Creased
	450	10 seconds	Not Creased
	300	5 seconds	Creased
	450	5 seconds	Not Creased
	Control		Creased
Most color on the fabric	470	5 seconds	Not Creased
	*450	15 seconds	Not Creased
	*470	10 seconds	Not Creased
	*470	15 seconds	Not Creased

*Very green and dull.

All samples dyed together in the same dyebath at 185° F. for 1 hour, using 5% Acetic Acid.

Chart XVIII. Celanese Pure Blue B

	Temperature of Pretreatment	Time of Pretreatment	Appearance after Dyeing
Least color on the fabric	400° F.	15 seconds	Not Creased
	400	10 seconds	Not Creased
	450	5 seconds	Not Creased
	300	15 seconds	Creased
	300	10 seconds	Creased
	350	10 seconds	Slightly Creased
	400	5 seconds	Slightly Creased
	350	5 seconds	Creased
	300	15 seconds	Creased
	350	15 seconds	Slightly Creased
Most color on the fabric	Control		Creased
	*470	5 seconds	Not Creased
	*470	10 seconds	Not Creased
	*450	10 seconds	Not Creased
	*450	15 seconds	Not Creased
	*470	15 seconds	Not Creased

*Progressively greener and duller.

All samples dyed together in the same dyebath at 185° F. for 1 hour, using a dispersing agent.

Chart XIX. Eastone Blue B. G. F.

	Temperature of Pretreatment	Time of Pretreatment	Appearance after Dyeing
Least color on the fabric	250° F.	10 seconds	Not Creased
	400	15 seconds	Not Creased
	350	15 seconds	Not Creased
	350	10 seconds	Slightly Creased
	400	5 seconds	Not Creased
	450	5 seconds	Not Creased
	300	10 seconds	Slightly Creased
	450	10 seconds	Not Creased
	350	5 seconds	Creased
	470	5 seconds	Not Creased
	450	15 seconds	Not Creased
	300	15 seconds	Creased
	Control		Creased
Most color on the fabric	470	10 seconds	Not Creased
	470	15 seconds	Not Creased

All samples dyed together in the same dyebath at 185° F. for 1 hour, using a dispersing agent

creased time of exposure to dry heat. *Chart XVIII.*

This demonstrates the characteristics shown by dyeings of the Anthraquinone dyestuff, Celanese Pure Blue B. *Chart XIX.*

The final color of the dyeings produced with the Azo Acetate dyestuff, Eastone Blue B. G. F., is not influenced by the yellow color of the nylon caused by heat treating at the higher temperatures.

CONCLUSIONS

1. Nylon shrinks when heated, and this shrinkage can be fixed by the use of dry heat. The higher the temperature of treatment or the longer the time, the more permanent the "set."
2. Nylon can be damaged by dry heat. This damage is indicated by a loss in tensile strength and elasticity. The fiber is also made more yellow in color by the higher temperatures.
3. Heat treated nylon fabrics can be dyed without forming creases in the fabric, provided the temperature of pretreatment is sufficiently high.
4. Some dyestuffs dye heat damaged nylon to a greater depth than undamaged nylon, whereas other dyes show a loss in color value with increasing temperature of pretreatment.

ACKNOWLEDGMENT

The committee was aided in the work covered in this report by:

The Hellwig Dyeing Corporation
Proctor and Schwartz, Inc.
E. I. du Pont de Nemours & Co., Inc., Technical Laboratory.

—♦ ♦—

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CALENDAR OF COMING EVENTS

Meeting, Philadelphia Section, January 18, 1946.

Meeting, Rhode Island Section, Providence Engineering Society Hall, 195 Angell Street, Providence, R. I., January 25, 1946.

Meeting, Northern New England Section, Hotel Manger, Boston, Mass., January 25, 1946. Speakers: Kenneth R. Fox, President, Lowell Textile Institute, "Modern Textile Education—Natural or Synthetic"; Dr. Kenneth P. Monroe will present the N. N. E. Section's Contest Paper.

Meeting, New York Section, Downtown Athletic Club, 19 West Street, New York City February 15, 1946.

Meeting, Mid-West Section, Bismark Hotel, Chicago, Ill., February 16, 1946.

Meeting, Rhode Island Section, February 22, 1946.

Meeting, Philadelphia Section, March 1, 1946.

Meeting, New York Section, Downtown Athletic Club, New York City, March 15, 1946.

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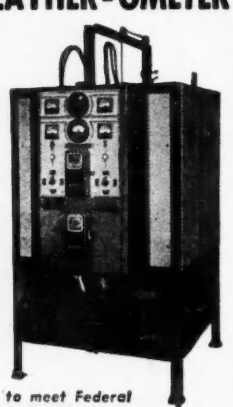

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(*Additional Classified's on Page XXXV*)

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WANTED TECHNICAL SALES ASSISTANT: — Rare opportunity to become permanently connected with nationally recognized manufacturer of textile processing specialties. Prefer graduate of textile institute with mill experience. Will act as assistant to District Manager covering Pennsylvania, Maryland, Delaware, Virginia. Salary plus bonus. Write giving complete educational and business background. Replies held in strict confidence. Our organization knows of this advertisement. Box 798.

POSITION WANTED:—Dyer 34 years old, 15 years experience, cotton, rayon, acetate crepe piece goods, and knit products, some finishing experience. Box 799.

CONFIDENTIAL EMPLOYMENT SERVICE — We invite correspondence (confidential) with Dyers, Chemists, Colorists, Superintendents, Master Mechanics, Office Managers, and others seeking positions and with employers seeking high-grade men to fill vacancies or to make replacements. Charles P. Raymond Service, Inc., 294 Washington St., Boston, Mass. Over forty-five years in business.

POSITION WANTED: Lowell Textile graduate, five years practical experience in finishing and dyeing rayon, acetate and woolen fabrics; also laboratory work with resins and textile specialties. Also consider sales or demonstration work. Veteran. Box 805.

(*Additional Classified's on Page XXXIV*)

Look at it from the standpoint of energetic laboratory research; look at it from the standpoint of manufacturing capacity; look at it from the standpoint of product results — whichever way you look at it ATCO is an accepted synonym for QUALITY with textile men everywhere.

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Wool Oils
Delustrants
Liquid Slip Proofs
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Finishing Compounds
and many other leading textile chemicals

Atlantic Chemical Co.
MAIN PLANT: CENTREDALE, RHODE ISLAND
BRANCH OFFICE: PATERSON, NEW JERSEY

ARKANSAS Products

Serve Dependably ★

FUNGICIDE: A mildew proofer made in various types to meet all government specifications.

ARKO FIRE RETARDANT: For flame-proofing uniform cloth, felt and all types of rayon and cotton fabrics including theatrical drapes.

***AQUAROL:** A water repellent for uniforms, overcoatings and other military fabrics; also all civilian garment cloth.

***PARAMINE:** A cation active softener for processing cotton and rayon cloth to obtain a soft, smooth, pleasing fininsh.

***ALGEPON P.:** A retarding agent for vat and sulphur dyeing to prevent premature oxidation of the dye-stuff or in other processes when necessary to retard exhaustion to obtain a uniform shade.

***PARAPON S. A.:** A highly efficient leveller and softener used in dyeing and finishing all types of viscose and acetate rayon. Excellent for processing tricot cloth.

***CULOFIX:** Used as an after treatment in last rinse to prevent bleeding of direct dyed cotton or rayon in water.

***DIAZONOL A. C.:** For boiling out cotton cloth in pressure or open kiers to produce greater absorbency and cleaner material. Excellent for preboiling knitted cloth in preparation for chlorine bleach. Also used with good results for boiling out cotton or rayon cloth on the jig.

***LANITOL:** An exceptional scouring agent and soap assistant, reduces cost and improves results of all boil-off or soaping operations.

***TETRANOL 1638:** A rapid and powerful wetting and penetrating agent. Active in acid, alkaline and salt solutions and not affected by hard water, may be used in all types of dyeing operations to insure positive penetration of color and a uniform and solid shape.

And a Complete Line of Oils, Chemicals, Softeners and Finishes For Wet Processing All Textile Fibres

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